



ORIGINAL ARTICLE

# Measuring dental students' preference: A comparison of light microscopy and virtual microscopy as teaching tools in oral histology and pathology



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## KEYWORDS

Virtual microscopy;  
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**Abstract Objectives:** Light microscopy used to be the traditional modality of teaching histology and pathology disciplines. Recent advances and innovations in the information technology field have revolutionized the use of hard- and software in medical education. An example of such an innovation is the so-called virtual microscopy. Many schools have started to adopt virtual microscopy as a new method aimed at enhancing student learning. Nonetheless, few reports have described the experiences of introducing virtual microscopy in dental education. We conducted this study to evaluate student perceptions of virtual microscopy use.

**Materials and methods:** A survey of 9 items with a five-point Likert scale was designed to assess student perceptions of different aspects of virtual microscopy use compared with light microscopy. Eighty-seven 2nd year dental students answered the survey for a response rate of 80%.

**Results:** The majority of the students (85.1%) reported positive feedback for the use of virtual slides as a method of learning. Students reported significantly higher scores in virtual microscopy compared with light microscopy ( $t$  test:  $t_{86} = 9.832$ ,  $P < 0.0001$ ); however, a few students reported some technical difficulties when using computers to view the virtual slides.

**Conclusions:** Although light microscopy is the classical tool of teaching histology and pathology, virtual microscopy is a highly preferred substitute. We believe that virtual microscopy is a valuable teaching tool that enhances student educational experiences.

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## 1. Introduction

Traditionally, histology and pathology education has been carried out using glass slides and light microscopy (LM). Light microscopy is the main and classical modality for medical education in the pathology laboratory (Hightower et al., 1999). Nevertheless, conventional microscopy is time consuming

and requires microscopy equipment and supplies (Kim et al., 2008). Additionally, LM requires several sectioned tissues that usually do not demonstrate all of the structures of interest (Blake et al., 2003; Bloodgood and Ogilvie, 2006).

More recently, many technological approaches have been utilized to enhance student learning experiences of histological sections. These approaches include the use of digitized images (Cotter, 2001), web-based animations (Brisbourne et al., 2002) and virtual microscopy (VM) (Hamilton et al., 2012). Since the beginning of the 21st century, there has been rapid technological advancement, particularly in the use of computers and the web, in medical education, including VM (Paulsen et al., 2010).

Virtual microscopy is a technology where microscopic glass slides are digitally reproduced and then viewed on a computer screen (Paulsen et al., 2010). As previously reported, there are numerous educational advantages for adopting VM. VM has been shown to enhance student learning experiences (Krippendorf and Lough, 2005). Another key benefit of VM is that an unlimited number of students can study slides at the same time (Krippendorf and Lough, 2005). Additionally, virtual slides can be digitally annotated where specific areas of diagnostic relevance can be labeled (Kolesnikov et al., 2001). These slides do not deteriorate and are easily duplicated, stored and managed (Kumar et al., 2006).

Therefore, several medical and training institutes have started integrating VM into their curriculum (Blake et al., 2003; Farah and Maybury, 2009; Kumar et al., 2006). A few reports have described their experiences in introducing VM in dental education (Farah and Maybury, 2009; Weaker and Herbert, 2009); however, there are no detailed comparisons between VM and LM concerning dental student preferences. In addition, there is a lack of literature regarding the perspectives of Saudi dental student use of virtual slides. The aim of this study was to compare the virtual microscope to the light microscope to assess student perceptions concerning the influence of virtual microscopy on their learning.

## 2. Materials and methods

The study survey and informed consent forms were reviewed and approved by the College of Dentistry Research Center, King Saud University. All students contributed to this study based upon confidential and voluntary participation.

King Saud University College of Dentistry has been applying VM technology in oral histology and pathology courses since the 2011–2012 academic year. Aperio's ScanScope System (Aperio Technologies, Aperio Technologies Inc., USA) has been used to scan slides and prepare the VM files. The students are loaned the CD-ROMs containing the virtual slides where they can view them through (Aperio's ImageScope) the viewer using their personal computers.

We asked second year dental students who used both VM and LM in oral histology and oral pathology to complete a survey. We designed the survey to assess student perceptions of different aspects of performance of VM compared with LM. A 9-item, five-point Likert scale was used for both microscopies as follows: 5 = Strongly Agree, 4 = Agree, 3 = Undecided, 2 = Disagree, and 1 = Strongly Disagree. The total score for each item was summed accordingly. The individual scores for the virtual and light microscopies were also calculated with a maximum possible score of 45 and a minimum

score of 9, where a higher score indicated greater preference. The statements are shown in Table 1 and 2. Two open-ended qualitative questions for each microscope type were also included. We requested that the students specify if they faced any additional technical problem using VM or LM. We also asked the students to state the reasons if they enjoyed learning with VM or LM. The computer program SPSS (Statistical Package for Social Science, version 21) was used for the data analysis. Paired two-tailed t-tests were used to detect the differences between the mean scores of responses for each of the 9 matched items (light vs. virtual) and the overall score. A critical P value of 0.05 was regarded as significant.

## 3. Results

The surveys were completed by 87 s year dental students (out of 109), including 48 males and 39 females, for an overall response rate of 80%. The normality of distribution was tested using the Kolmogorov–Smirnov test. The reliability of scale was measured by a reliability coefficient and Cronbach's  $\alpha$  = (0.766, 0.870) for VM and LM. The data shown in Table 1 and Table 2 are presented as the percentages of students in agreement or disagreement with a specific statement. The majority of students (85.1%) agreed or strongly agreed with the statement indicating that they preferred the virtual microscope to the light microscope. The data also indicated that the images provided by VM (87.2%) were of sufficient magnification to allow examination of the tissues in great detail compared with LM (44.8%). Eighty-five percent of the students disagreed or strongly disagreed with the statement indicating that they were able to use LM outside of scheduled times.

Table 3 shows the comparisons between the VM and LM scores using a paired two-tailed t-test. The students gave significantly higher scores to VM compared with LM (*t* test:  $t_{86} = 9.832$ ,  $P < 0.0001$ ). When the items were evaluated separately, all of the items showed a highly significant difference between the two microscopes, with VM being the more preferred option. One exception is item number nine, "I did not face any technical problems using virtual microscopes", which showed no significant difference.

Not all of the students offered written answers on the qualitative part of the survey; however, the comments were generally supportive of VM. Approximately 11 students commented that "they enjoyed learning with the virtual microscope because of its ease of use", whereas others stated that "because virtual microscopy can be used anywhere and anytime". Other comments included "because the microscope doesn't hurt my eyes and has less light exposure" and "because it saves me time". On the other hand, in response to "If you enjoyed learning with the light microscope, please answer why", very few students offered answers to this question. Answers included "the light microscope allowed me to directly examine a slide without technical issues" and "I like to work by hand and not computer". Regarding the technical problems faced by students, six students indicated that they experienced some difficulties with VM using Mac operating systems. One student offered, "VM files are large in size", and another wrote "Virtual slides sometimes freeze." A sample of student comments on LM included the following: "Orienting and adjusting the LM was difficult", "LM is heavy and slides are easily broken", "Adjustment of the fine object is challenging" and "I can't label the slide".

## 4. Discussion

Based on the formative assessment carried out in this study, our students accept VM as a preferred tool to facilitate learning.

Our students offered significantly higher ratings to the items of VM vs. LM, which is consistent with previous studies

**Table 1** Student evaluation of virtual microscopy by number and percentage of total respondents.

Question item	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Total
1 I preferred the virtual microscope to the light microscope	42(48.3%)	32(36.8%)	6(6.9%)	4(4.6%)	3(3.4%)	87(100%)
2 Using virtual microscopy I can manage my time effectively	28(32.2%)	39(44.8%)	14(16.1%)	2(2.3%)	4(4.6%)	87(100%)
3 Directions for use of the virtual microscope were clear for me	24(27.6%)	39(44.8%)	17(19.5%)	3(3.4%)	3(3.4%)	86(98.9%)
4 The virtual microscope had adequate magnification to allow me to examine the tissues in great details	36(41.4%)	39(44.8%)	8(9.2%)	3(3.4%)	0(0%)	86(98.9%)
5 I navigate the slides with the virtual microscope easily	30(34.5%)	41(47.1%)	11(12.6%)	4(4.6%)	1(1.1%)	87(100%)
6 The virtual microscopy allowed me to cooperate with other students	31(35.6%)	40(46%)	10(11.5%)	4(4.6%)	2(2.3%)	87(100%)
7 I was able to use the virtual microscope outside the scheduled class time	33(37.9%)	34(39.1%)	10(11.5%)	5(5.7%)	4(4.6%)	86(98.9%)
8 The virtual microscope helped me learning the subject	27(31%)	45(51.7%)	14(16.1%)	1(1.1%)	0(0%)	87(100%)
9 I did not face any technical problems using virtual microscopes	14(16.1%)	23(26.4%)	18(20.7%)	25(28.7%)	7(8%)	87(100%)

**Table 2** Student evaluation of light microscopy by number and percentage of total respondents.

Question item	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree	Total
1 I preferred the light microscope to the virtual microscope	3(3.4%)	6(6.9%)	9(10.3%)	49(56.3%)	20(23%)	87(100%)
2 Using light microscopy I can manage my time effectively	4(4.6%)	11(12.6%)	10(11.5%)	49(56.3%)	13(14.9%)	87(100%)
3 Directions for use of the light microscope were clear for me	10(11.5%)	37(42.5%)	15(17.2%)	17(19.5%)	7(8%)	86(98.9%)
4 The light microscope had adequate magnification to allow me to examine the tissues in great details	9(10.3%)	30(34.5%)	16(18.4%)	22(25.3%)	10(11.5%)	87(100%)
5 I navigate the slides with the light microscope easily	7(8%)	24(27.6%)	20(23%)	24(27.6%)	12(13.8%)	87(100%)
6 The light microscopy allowed me to cooperate with other students	4(4.6%)	18(20.7%)	16(18.4%)	33(37.9%)	15(17.2%)	86(98.9%)
7 I was able to use the light microscope outside the scheduled class time	2(2.3%)	4(4.6%)	11(12.6%)	32(36.8%)	38(43.7%)	87(100%)
8 The light microscope helped me learning the subject	5(5.7%)	34(39.1%)	23(26.4%)	17(19.5%)	8(9.2%)	87(100%)
9 I did not face any technical problems using light microscopes	14(16.1%)	24(27.6%)	20(23%)	20(23%)	9(10.3%)	87(100%)

(Farah and Maybury, 2009; Kolesnikov et al., 2001). The majority of students indicated that the images provided by VM were of sufficient magnification compared with LM. Virtual images are usually produced when the slide is in focus, with proper condenser and light adjustment, whereas light microscope slides need to be adjusted by the students, which requires time and skills in operating the microscope. Most of the students disagreed or strongly disagreed with the statement indicating that they were able to use the LM outside of scheduled times. Light microscope laboratories were open during specific hours, whereas the open availability of VM was taken advantage of by our participants. Furthermore, with the use of virtual slides, the students felt that their time was being used more effectively because of the ability to find relevant areas of the slide quickly. Some students commented that they have eye related physical discomfort when using light microscopes,

which was also found by a previous study (Farah and Maybury, 2009). On the other hand, our results indicated the issue of compatibility with Mac users experiencing some difficulties running VM on their operating system, which was consistent with another study (Weaker and Herbert, 2009). Regarding the complaint that VM files are large in size, we are considering changing to a web-based approach to view images to alleviate this problem. Our participants noted some disadvantages of using LM, which included the following: difficulty in adjusting and orienting the slides, breakability of the slides and inability to label histological structures on the slides.

Different reports have been published that would support the use of VM as a teaching methodology for medical students. Krippendorf and Lough (2005) described their experience in switching from LM to VM for teaching medical histology. The authors found that both students and faculty very

**Table 3** The comparisons between VM and LM scores using Paired two-tailed t-test.

Types of laboratory	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Total scores
VM	$n = 87$ $M = 4.22$ $SD = 1.01$	$n = 87$ $M = 3.98$ $SD = 1$	$n = 86$ $M = 3.91$ $SD = 0.97$	$n = 86$ $M = 4.26$ $SD = 0.77$	$n = 87$ $M = 4.09$ $SD = 0.87$	$n = 87$ $M = 4.08$ $SD = 0.93$	$n = 86$ $M = 4.01$ $SD = 1.08$	$n = 86$ $M = 4.13$ $SD = 0.71$	$n = 86$ $M = 3.14$ $SD = 1.23$	$n = 87$ $M = 35.67$ $SD = 5.10$
LM	$n = 87$ $M = 2.11$ $SD = 0.96$	$n = 87$ $M = 2.36$ $SD = 1.03$	$n = 86$ $M = 3.30$ $SD = 1.16$	$n = 87$ $M = 3.06$ $SD = 1.22$	$n = 87$ $M = 2.89$ $SD = 1.20$	$n = 86$ $M = 2.57$ $SD = 1.14$	$n = 87$ $M = 1.85$ $SD = 0.97$	$n = 87$ $M = 3.12$ $SD = 1.09$	$n = 87$ $M = 3.16$ $SD = 1.25$	$n = 87$ $M = 24.37$ $SD = 7.02$
$t$	10.683	8.686	3.114	6.878	7.002	7.644	11.474	6.796	-0.118	9.832
$P$ value	$P < 0.0001$	$P < 0.0001$	$P = 0.003$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P = 0.906$	$P < 0.0001$

M: mean, SD: standard deviation.

favorably received this method. Additionally, the authors found that data from examination scores and course evaluation surveys indicated that use of the virtual microscope may significantly improve student performance and learning efficiency. Another study by Kumar et al. (2004) reported their implementation of teaching microscopic pathology with virtual slides and their use in summative assessment, where both students and teaching staff adapted to the use of VM. The authors found that virtual slides solved a number of problems in student learning, while providing good to excellent image quality. Moreover, Blake et al. (2003) described how they changed a histology course from using glass slides and microscopes to using virtual slides and virtual microscopes. Blake et al. reported that both students and faculty have shown strong support for using this approach to teaching histology.

VM applications have been implemented in dental education. Farah and Maybury (2009) described their experience in implementing VM technology and found that dental students are in favor of VM. Weaker and Herbert (2009) changed the dental histology courses from a light microscope lab to a total VM lab and found a significant improvement.

## 5. Conclusions

In summary, VM is a highly preferred substitute for LM for teaching oral histology and pathology to dental students. A debate can be raised that dental students must learn how to use the real conventional microscope. Most if not all practicing dentists do not use microscopes. Additionally, the goal of oral histology and pathology education is to teach dental students normal and abnormal oral and maxillofacial structures, not how to use a microscope; however, we believe that it is essential to briefly expose the students to conventional microscopes and glass slides during their general medical education so that they appreciate the concepts of histology and virtual images. Nevertheless, we recommend applying VM in oral histology and pathology education.

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