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Impact of virtual microscopy with conventional microscopy on student learning in dental histology

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ABSTRACT

Background: In dental histology, the assimilation of histological features of different dental hard and soft tissues is done by conventional microscopy. This traditional method of learning prevents the students from screening the entire slide and change of magnification. To address these drawbacks, modification in conventional microscopy has evolved and become motivation for changing the learning tool. Virtual microscopy is the technique in which there is complete digitization of the microscopic glass slide, which can be analyzed on a computer. This research is designed to evaluate the effectiveness of virtual microscopy with conventional microscopy on student learning in dental histology.

Materials and Methods: A cohort of 105 students were included and randomized into three groups: A, B, and C. Group A students studied the microscopic features of oral histologic lesions by conventional microscopy, Group B by virtual microscopy, and Group C by both conventional and virtual microscopy. The students' understanding of the subject was evaluated by a prepared questionnaire.

Results: The effectiveness of the study designs on knowledge gains and satisfaction levels was assessed by statistical assessment of differences in mean test scores. The difference in score between Groups A, B, and C at pre- and post-test was highly significant. This enhanced understanding of the subject may be due to benefits of using virtual microscopy in teaching histology.

Conclusion: The augmentation of conventional microscopy with virtual microscopy shows enhancement of the understanding of the subject as compared to the use of conventional microscopy and virtual microscopy alone.

Key Words: Conventional microscopy, dental histology, student learning, virtual microscopy

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INTRODUCTION

In the medical school curriculum, the medical histology subject has been a long-standing basic science course worldwide. The dental histology subject is in the 1st year of Bachelor of Dental Sciences (I B.D.S.) curriculum in Dentistry as per the Dental Council of India regulations. In the dental histology curriculum, during routine practical training, the students have to assimilate the histological features of different dental hard and soft tissues. The histology slides are conventionally

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viewed under light microscope with a limited field of vision and magnification. To ensure that the same field is visualized by all the students, alteration of the field is not possible. This prevents the students from screening the entire slide. At the same time, visualization of the detailed structure of any part of tissue at higher magnification by change in objective is also not possible. Moreover, maintenance of an adequate slide collection is also difficult and increases the laboratory work. Apart from this, the slides need to be changed regularly to avoid fading of the dye or slide damage. Variability between sections in the slide collection often causes confusion among students and affects the success of teaching process. In addition, a large reserve of tissue is required to prepare a slide set for the whole class. To address these drawbacks, modification in conventional microscopy has evolved and become motivation for changing the learning tool. The use of technology in dental education has focused on patient simulation, complex data visualization, and student assessment.[1] The advent and rapid rise in sophistication of microcomputer technology have opened up new avenues for the presentation of image-intensive information, such as occurring in the histology laboratory.[2] In particular, the development of virtual microscopy has provided an alternative to the use of the microscope and glass slides in histology laboratory teaching that provides an experience similar to the use of the microscope and glass slides.[3] Virtual microscopy is the technique in which there is complete digitization of the microscopic glass slide, which can be analyzed on a computer. These virtual slides are high-magnification digital images of tissue sections, stored in a multi-resolution file format. These slides can be further viewed in a web browser that closely simulates the observation of glass slides with a real microscope, by using appropriate software.[4,5] In our study, we used the term virtual microscopy in context to the use of video-eyepiece and binocular light microscope attached to a liquid crystal display (LCD) projector.

Fred (Dick) Dee, a pathologist at the University of Iowa, is the pioneer in the introduction of the use of virtual slides in medical education. By 2000, the progressive decrease in the use of traditional microscopy in medical student education had set the stage for the entry of virtual microscopy into medical schools.[6] The successful study of histology requires a balance between conventional microscopy and virtual microscopy. In today's era of technology, virtual microscopy can become an important component of teaching–learning process to enhance knowledge and performance. This use of technology has been successful in the integration of traditional- and technology-based methods in the study of histology and to meet the challenges of training our future dental surgeons in the 21st century.[2] This innovative learning can have a big impact on the arena of self-directed learning. The present educational research was aimed to assess the efficacy of virtual microscopy on assimilation of dental histology, and with the objectives to evaluate the effectiveness of virtual microscopy and compare it with the conventional microscopy.

MATERIALS AND METHODS

Study participants

This educational research was carried out at the Department of Dental Anatomy, Embryology and Histology. The I B.D.S. students were included in the study. Students were selected using systematic random sampling. The total sample size was 105.

Study protocol

The study was approved by the Institutional Ethical Committee. The purpose and the methodology of the study were explained to the students, and after obtaining written informed consent, 105 students were enrolled in the study. Regarding content of the study, an informal discussion was carried out among faculty members. The topic from "Must Know" area of curriculum was selected unanimously for the study. Two didactic lectures of 1 h duration each which had already been delivered on the content were selected for the study. The cohort of 105 students of I B.D.S. was divided into three groups, Groups A, B, and C, randomly. The students were exposed to only theoretical knowledge of the content of the syllabus through didactic lectures.

Pre- and post-test

Pre- and post-tests comprised ten objective type questions based on histology from the selected content of syllabus which was prepared to evaluate the students' understanding of the subject. The same set of questions was used for the pre- and post-test. Standard textbooks of dental histology were used for the verification and validation of the answer key to the questions. The highest possible test score was 10. The acquired knowledge of the selected content of the syllabus was evaluated by pretest.

Group A students (n = 35) studied the microscopic features of oral histologic lesions by routine procedure of microscopic viewing, that is, using conventional microscope and glass slides; group B students (n = 35) studied by virtual microscopy, that is, video-eyepiece and binocular light microscope attached to LCD projector; and Group C students (n = 35) by both conventional as well as virtual microscopy. Then, the students' understanding of the subject was evaluated by a prepared questionnaire (posttest).

Students' feedback questionnaire

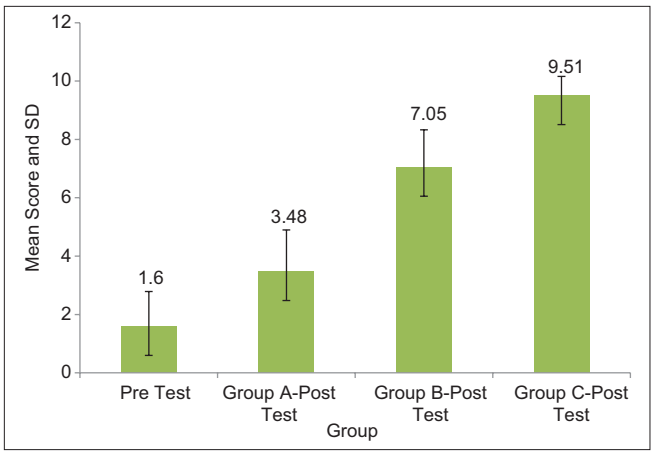
The students' perceptions regarding the new teaching-learning tool in dental histology were recorded on a questionnaire comprising ten items. Groups B and C students were enrolled for the feedback questionnaire. The responses for item number 1 to 8 were recorded on a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) while responses for item 9 were recorded on a 10-point scale (1 = not useful to 10 = very useful). Item 10 was an open-ended question and students were asked to give their comments.

Data analysis and statistics

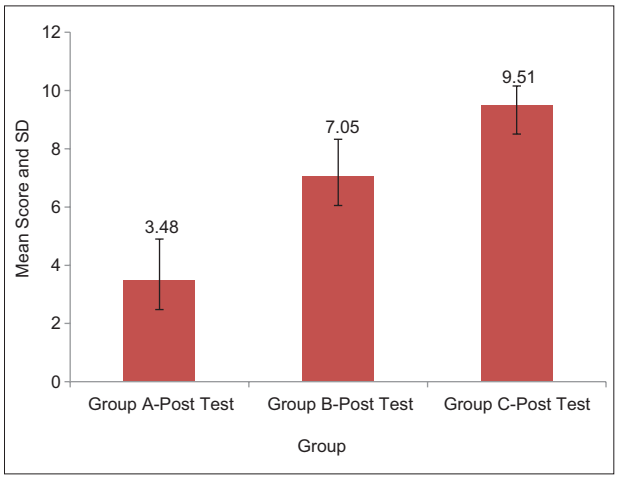
Data analysis was carried out using SPSS 17.0 version 8. Statistical significance was set at $P < 0.05$. Quantitative data analysis comprised pre- and post-test score comparison between and within groups, students' feedback on a 5-point Likert scale, and usefulness of virtual microscopy on a 10-point scale. Student's paired t-test was used to compare pre- and post-test scores. The comparison of pre- and post-test scores between and within the groups was carried out by using one-way analysis of variance (ANOVA) and multiple comparisons by Tukey's test. Student's responses to items 1–8, recorded on a 5-point Likert scale questionnaire, were expressed as percentages. Student's responses to item 9 in the questionnaire (10-point scale for usefulness) were categorized as follows: 1–2 = not useful; 3–4 = slightly useful; 5–6 = moderately useful; 7–8 = useful; and 9–10 = very useful. Comments in response to item 10 were evaluated qualitatively.

RESULTS

The effectiveness of the study designs on knowledge gains and satisfaction levels was assessed by statistical assessment of differences in mean test scores. The mean test score at pretest in Groups A, B, and C was 1.6 ± 1.19. The significantly improved post test score was observed in Group A (3.48 ± 1.42), Group B (7.05 ± 1.28), and Group C (9.51 ± 0.65). The comparison of scores in the three groups at pre- and post-test was done by Student's paired t-test and found to be statistically significant ($P < 0.05$). [Graph 1]. One-way ANOVA showed high significant variation ($P < 0.05$) of the mean squares (321.629) between groups and (1.366) within groups with the degree of freedom (df) between groups (df = 2.00) and within groups (df = 102). It shows that statistically significant variations of means of the post test scores were found among all the groups [Graph 2]. Multiple comparison among all the



Graph 1: Comparison of score in Groups A, B, and C at pre- and post-test. Group A - (n = 35) - Conventional microscopy. Group B - (n = 35) - Virtual microscopy. Group C - (n = 35) - Conventional microscopy and virtual microscopy.



Graph 2: Comparison of score in Groups A, B, and C at post test. Group A - (n = 35) - Conventional microscopy. Group B - (n = 35) - Virtual microscopy. Group C - (n = 35) - Conventional microscopy and virtual microscopy.

groups by Tukey's test showed statistically significant difference ($P < 0.05$) [Table 1].

Overall, 87.61% of the students strongly agreed that the virtual microscopy was useful as a practically oriented teaching–learning tool and shows enhanced learning. Nearly 85.71% of the students strongly agreed that virtual microscopy should be incorporated in the dental histology curriculum as a teaching–learning tool. The usefulness of virtual microscopy as recorded on a 10-point rating scale was useful with a mean of 0.30 whereas it was found to be very useful with a mean of 0.19. Thus, according to the categorization of scores, 60% of the students found this intervention useful whereas 40% perceived its educational value as very useful. Free comments in response to item 10 in the questionnaire were analyzed and categorized as strengths and suggestions.

DISCUSSION

This study assessed the educational effectiveness of virtual microscopy in the first-year dental histology course at Sharad Pawar Dental College and Hospital, Wardha. This research compared the effectiveness of virtual microscopy with conventional microscopy as a tool for student learning. In routine study of dental histology, the assimilation of the histological features of different dental hard and soft tissues is done by conventional microscopy. This traditional method of studying histology has its limitations that it prevents the students from screening the entire slide and change of magnification. Keeping these drawbacks of conventional microscopy in mind, we designed this research to evaluate the effectiveness of virtual microscopy on student learning in dental histology.

We evaluated the educational effectiveness of virtual microscopy by comparing scores at pre-and post-test in Groups A, B, and C. Sequential statistically significant improvement was observed in Groups A, B, and C at post test scores. This could be explained on the basis of increased efficiency of the teaching methodology that is virtual microscopy. The augmentation of conventional microscopy with virtual microscopy shows enhancement of the understanding of the subject as compared to the use of conventional microscopy and virtual microscopy alone. This enhanced understanding of the subject may be due to the following benefits of using virtual microscopy in teaching histology. (1) The important aspect of translating the image and thus gaining panoramic perspective of the whole microscopic specimen, not just a single microscopic field is achieved by virtual microscopy. (2) The capability of virtual microscopy to zoom an image and thus study the features or structures at various magnifications which is also a distinct advantage over static image. (3) Slides could be easily annotated to help the students to establish a deeper understanding. (4) Simultaneous explanation of the lesion to the large number of beneficiaries was possible. (5) Discussions among the students and faculty members were made easy. (6) In the study of histology, at the U.G level, pattern recognition often becomes a matter of rote learning. The bigger and more comprehensive view presented by virtual microscopy was more conducive for learning. (7) Improving the quality of faculty–student interactions and supporting a paradigm shift from teaching to learning. (8) Teachers can manage their time effectively to reinforce knowledge and skills. (9) The learning methodology can become more student centric. Integration of all of these amendments led to better retention of knowledge as measured by post test scores [Graph 2]. Thus, students are exposed to technology and perhaps to the principal method of content distribution in future clinical settings.

Table 1: Multiple Comparison of score in Group A, B, and C Tukey Test

Groups	Mean Difference	SE	*P*	95% CI	
				Lower bound	Upper bound
Group A & B	3.57	0.27	0.000 *P*<0.05(s)	2.90	4.23
Group A & C	6.02	0.27	0.000, *P*<0.05(s)	5.36	6.69
Group B & C	2.45	0.27	0.000, *P*<0.05(s)	1.79	3.12

Group A (*n*=35): Conventional microscopy; Group B (*n*=35): Virtual microscopy; Group C (*n*=35): Conventional microscopy and virtual microscopy. S: Significant; SE: Standard error; CI: Confidence interval

These amendments of virtual microscopy as seen in our study were similar to the study at the University of South Carolina School of Medicine, North America, by Blake *et al*., who submitted the first report of a successful complete transition from the use of microscope glass slides and microscopes to the combined use of static-labeled images and virtual slides and virtual microscopes for the teaching of laboratory sessions in medical histology courses.[7] To identify trends in the number of hours of histology laboratory instruction that each medical student receives, the amount of faculty effort devoted to histology laboratory instruction, and the use of various computer-based technologies (including

virtual microscopy and virtual slides) in histology laboratory instruction, a web survey was designed by Bloodgood and Ogilvie. They found that the clear trend has been toward a blending of the new computer-based instructional technologies with the long-standing use of microscopes and glass slides.[2] Technology for acquisition of virtual slides was developed in 1985, however the application to education was in progress from the late 1990s. Our results were in accordance with that of Harris *et al*. and Heidger *et al*. who conducted a study to assess the potential effectiveness of using virtual slides on the web in their medical histology course. Students compared the two viewing approaches and rated the virtual slides and virtual microscopes highly. Since then, the virtual slides and virtual microscopes have been integrated successfully into the laboratories in histology along with microscope glass slides and light microscopes.[8,9] Similarly, Goldberg and Dintzis in 2007 studied the impact of team-based virtual microscopy on student learning in physiology and histology at The Johns Hopkins School of Medicine. Team-based virtual microscopy and online learning were found to be very useful. It was used to transform the first-year physiology and histology course into a student-centered learning environment.[1] In 2009, Fred R. Dee stated that virtual microscopy was beginning to play an increasing role in continuing education, house staff education, and evaluation of competency in histopathology. He stated that as Z-axis viewing (focusing) became more efficient, virtual microscopy would also become integrated into education in cytology, hematology, and microbiology.[6] To determine the effect of the virtual microscopy on overall student performance, Weaker and Herbert in 2009 compared student grades in dental histology before and after the introduction of the virtual microscopy. Even in the presence of a different testing format, they found that there was no significant difference in the final averages over the 7 years prior to (84.2 ± 0.9 standard deviation [SD]) or the 5-year period following (82.9 ± 1.6 SD) its introduction. Thus, the transition of the dental histology course at the University of Texas Health Science Center at San Antonio Dental School was gradually completed over a 5-year period.[10] At the University of New South Wales, Kumar *et al*. designed practical classes around virtual slides. They integrated the teaching of histology and histopathology, introducing students to the microscopic features of tissues and organs and giving them the opportunity to compare and contrast the normal with the abnormal in various disease states. Evaluation of this program revealed that students strongly supported the integrated approach.[11] To assess the educational impact of changing from light microscopy to virtual microscopy, Krippendorf and Lough compared the mean laboratory examination scores of students who learned through virtual microscopy with those of students who learned through the light microscope. They found that the switch from light microscopy to virtual microscopy was very favorably received by both students and faculty. More importantly, data from examination scores and course evaluation surveys indicated that use of virtual microscope may significantly improve student performance and learning efficiency. They have found that for the purpose of teaching and learning histology at the level of first-year medical students, virtual microscopy is a highly effective and popular substitute for light microscopes and glass slides. The virtual microscope offers the advantages of reduced cost and maintenance while retaining the positive features of light microscope-based instruction.[12]

Thus, the incorporation of the virtual microscopy in the teaching of histology and histopathology is, in our experience, an important new learning modality, fully justified in being included as an important learning resource for any modern course in histology. It links the ease of use and quality of image with ultimate accessibility for study with many of the advantages of the conventional light microscope.

CONCLUSION

Implementation of virtual microscopy as the teaching methodology in the field of dental histology can become an important new learning modality. Virtual microscopy has many advantages over conventional microscopy and it complements conventional microscopic evaluation of slides. Although merits of conventional microscopy cannot be overruled, the virtual microscopy finds important niche in various tools of teaching and learning methods. Therefore, the use of virtual microscopy as observed in this educational research has the potential to enhance student learning of dental histology. Thus, the virtual microscopy may be useful for better integration of traditional- and technology-based methods in the study of histology. It is amenable to individuals as well as small-group study venues and also for tutorial use.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial, in this article.

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