Comparison of virtual microscopy and real microscopy for learning oral pathology laboratory course among dental students

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Abstract  Background/Purpose: Virtual microscopy has been used for teaching general and oral pathology laboratory course for more than 10 years. This study aimed to share the learning experience of an oral pathology laboratory course using either the virtual microscopy with digitalized virtual slides (virtual slide learning) or real microscopy using traditional glass slides (glass slide learning) among dental students.  Materials and methods: Thirty-eight undergraduate dental students who took the compulsory course entitled “oral pathology” in the School of Dentistry, National Taiwan University were included in this study. The questionnaires were filled and final test was taken by these students after finishing the teaching of oral pathology laboratory course using either virtual or glass slide learning. The data were collected and analyzed statistically.  Results: Our results showed a significantly higher acceptance rate (all $P$-values $< 0.001$) and a significantly better histopathological diagnosis ability ($P < 0.01$) among dental students using...
the virtual slide learning than those using the glass slide learning for the oral pathology laboratory course.

Conclusion: Virtual microscopy has many advantages over real microscopy in oral pathology laboratory course teaching. Based on the results of our study, we believe that the virtual microscopy with digitalized virtual slides may gradually replace the real microscopy with glass slides for the learning of oral pathology laboratory course. We foresee that the virtual microscopic images of the patients’ specimens may be added in the patients’ digital medical charts in addition to the images of computerized tomography, magnetic resonance imaging, and sonography in the future.

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Introduction

The contents of dental practices are prevention, diagnosis, and treatment of diseases in the oral and maxillofacial region with medical and dental knowledge. The dentists also provide the consultation for oral health. In fact, general dentists still have the responsibility of discovering and diagnosing common diseases in the oral and maxillofacial region, uncommon but life-threatening diseases (such as oral cancers), and rare odontogenic tumors or cysts (only dentists have professional training for diagnosis and treatment of these types of diseases). Therefore, it is generally accepted internationally that dental students and dentists should still learn the oral pathology course. However, a major challenge for educators today is how to teach the oral pathology course and what contents in the field of oral pathology have to be included for teaching the undergraduate and graduate students in dental schools, so that the curriculum is relevant to a practicing dentist and a dental specialist. Teachers of oral pathology are ultimately responsible for the patients, who have the right to expect dentists to have a broad knowledge of oral pathology that can be extended beyond the most common oral lesions or conditions.

In the School of Dentistry, National Taiwan University, the oral pathology laboratory course is scheduled in the first semester of the third year of undergraduate students for 4 h per week, and the class size is usually within 40 students. For the past 60 years, standard classroom teaching of oral pathology laboratory course using the real optical microscope to observe prepared tissue sections on glass slides is carried out in our dental school. With recent advances in the technology of virtual microscopy, it is now feasible for microscopic glass slides to be transformed into digitized virtual slides, and then the dental students can study the oral histopathology course through computer at any places with the broadband internet available by means of a virtual microscopy.

In 2015, a teaching improvement plan for our oral pathology course was developed to update traditional glass slides to digitalized virtual slides with the use of virtual microscopy system. Thus, we got the opportunity to compare the students’ acceptance rate and changes in oral histopathological diagnosis ability after finishing the teaching of oral pathology laboratory course using either the real microscopy with traditional glass slides (so-called glass slide learning) or the virtual microscopy with digitalized virtual slides (so-called virtual slide learning). The use of virtual microscopy system can provide better quality and more stable virtual microscopic images, so that students do not need a conventional optical microscope and can still learn the oral pathology laboratory course through virtual slide learning method using the stored virtual microscopic images in a server computer.

In this study, the effectiveness of teaching the oral pathology laboratory course using either glass or virtual slide learning was investigated. We tried to know whether there was a significantly higher acceptance rate or a significantly better histopathological diagnosis ability in dental students using the virtual slide learning than in dental students using the glass slide learning for the oral pathology laboratory course.

Materials and methods

The study of this teaching improvement plan was aimed to introduce the virtual microscopy system to the students and then to evaluate students’ acceptance rate and changes of their histopathological diagnosis ability after finishing the teaching of oral pathology laboratory course using either the glass or virtual slide learning.

Participants

A total of 38 undergraduate dental students who took the compulsory course entitled “oral pathology” in the School of Dentistry, National Taiwan University in the second semester of the third year of the university were included in this study.

Teaching process

In addition to the lectures and small group case discussions, we also use oral pathology laboratory classes to allow students to observe the histopathological features in tissue sections of oral and maxillofacial diseases and to help them to possess the ability to integrate the clinical features, radiographic manifestations, and histopathological features of the diseases together. The teaching process in this study was as follows: (1) This teaching improvement plan paid for
the preparation of digitalized virtual slides (the improved teaching materials) used for the virtual slide learning of part of oral pathology laboratory course, and the effectiveness of virtual slide learning was further compared with that of glass slide learning using traditional glass slides (the unimproved teaching materials). (2) We used oral disease as the category to compare whether the students had improved acceptance rate and increased overall histopathological diagnostic ability after virtual slide learning than after glass slide learning.

For making the digitalized virtual slides, we selected cases with typical histopathological manifestations from routine head and neck surgical pathology specimens. The glass slides of these cases were then turned into digitalized virtual slides which gradually replaced traditional glass slides of the same diagnosis in our existing oral pathology teaching slide set. Besides, we also used the virtual microscopy system equipment developed by the Department of Oral Pathology, Kaohsiung Medical University and its tissue slide image digitization service for making our own digitalized virtual slides.

### Evaluation methods

Our evaluation methods were divided into two parts: questionnaire survey and histopathological diagnosis ability assessment. We used questionnaire survey to evaluate the acceptance rate of the virtual microscopy or real microscopy system by the students. In terms of questionnaire survey, we produced "the questionnaire for evaluation of acceptance rate using either the glass or virtual slide learning for the oral pathology laboratory course". The content of our questionnaire included 7 questions for self-assessment of the students’ acceptance rate of using either the glass or virtual slide learning for the oral pathology laboratory course. For assessment of histopathological diagnosis ability, we used both glass and virtual slides of different oral disease entities to test students’ histopathological diagnosis ability.

### Statistical analysis

All data collected were stored in excel files and used for statistical analysis. The differences in the mean acceptance rates of various investigated items such as students’ learning effectiveness were compared between the glass and virtual slide learning methods for the oral pathology laboratory course by Student’s t-test. Moreover, the mean scores of student’s histopathological diagnosis ability test after finishing the teaching of oral pathology laboratory course using either glass or virtual slides were also compared by Student’s t-test. The result was considered to be significant if the P-value was less than 0.05.

### Results

In this study, we prepared a small number of virtual slides to replace traditional glass slides to compare the differences in students’ mean acceptance rates and mean scores of histopathological diagnosis ability test after finishing the teaching of oral pathology laboratory course using either glass or virtual slides. According to our observations at the teaching classroom, students generally responded well and had a high acceptance rate of virtual slide learning.

The questionnaire mainly focuses on the students’ acceptance rate of learning oral pathology laboratory course using either the glass or virtual slides. The students were asked to answer the following 7 questions regarding the learning of oral histopathology using either glass or virtual slides:

- Q1. This teaching method is very time-efficient.
- Q2. The operation method is very user-friendly.
- Q3. The histopathological image is very clear.
- Q4. Navigation of the learning system is very convenient.
- Q5. This teaching method is very helpful for me to learn histopathology.
- Q6. This type of microscope and slide is easy to view.
- Q7. This teaching method can stimulate my interest in learning histopathology.

The results of questionnaire survey are shown in Fig. 1 and Table 1. There were 37.22% (99/266) of students who accepted and agreed with the learning of oral histopathology using traditional glass slides, and among them 4.14% (11/266) of the students who strongly agreed. On the other hand, there were 85.71% (228/266) of students who accepted and agreed with the learning of oral histopathology using digitalized virtual slides, and among them 26.69% (71/266) of the students who strongly agreed (Fig. 1). Statistical analysis showed that the mean acceptance rates of 7 questions regarding the learning of oral histopathology were all significantly higher in dental students using the virtual slides than in dental students using the glass slides (Student’s t-test, all P-values < 0.001, Table 1).

The results of the final test of students’ histopathological diagnosis ability are shown in Fig. 2 and Table 1. The test scores represented students’ learning outcomes and their acquired histopathological diagnosis ability. Regarding the learning of oral histopathology using traditional glass slides, there were 0 and 23 students who obtained A and B grades in the test scores, respectively. On the other hand, for the learning of oral histopathology using digitalized virtual slides, there were 17 and 11 students who obtained A and B grades in the test scores, respectively. To convert A to E grades into 5 to 1 scores, we found that the mean test scores after the glass slide learning and virtual slide learning were 3.42 ± 0.89 (n = 38) and 4.11 ± 1.01 (n = 38), respectively. Statistical analysis showed that the dental students using the virtual slide learning obtained significantly better learning outcomes and significantly better histopathological diagnosis ability than the dental students using the glass slide learning (Student’s t-test, P < 0.01, Table 1).

### Discussion

The main purposes of oral pathology and diagnosis course are understanding the pathogenesis, clinical and histopatho-
logical features, treatment, and prognosis of a variety of oral and maxillofacial diseases, acquiring the ability of accurate diagnosis and treatment of oral and maxillofacial diseases, and recognizing the referral of patients with difficultly-handled oral and maxillofacial diseases to the specialists for further treatments. The ability of making accurate diagnosis of an oral and maxillofacial disease requires the knowledge in both clinical and pathological features of oral diseases. Good-quality, clear, and representative tissue sections and their histopathological images are the foundations for an excellent learning of the histopathology. Therefore, our oral pathology course provided a combined-learning through the lectures, small group case discussions, and histopathological diagnosis training using either the virtual microscopy with digitalized virtual slides or real microscopy with traditional glass slides to let dental students to have the knowledge and competence of diagnosis and treatment of oral and maxillofacial diseases.

The traditional teaching of oral histopathology using the real microscopy with glass slides has many shortcomings such as the high expense to maintain the microscopes and color-fading of the stained tissue sections on the glass slides. In addition, students cannot freely review the glass slides after class.

Due to advances in the technology of virtual microscopy, these help to develop a digitalized oral and maxillofacial pathology laboratory by using a virtual microscopy system and telepathology. Although the application of virtual microscopy technology and telepathology has seldom been described in the teaching of oral and maxillofacial pathology laboratory course in dental schools, it has already been applied in teaching of histology and pathology in some medical schools. The results of questionnaire survey in these studies indicated that virtual slide learning enhances students’ interest in learning microscopic histology/pathology over the traditional glass slide learning.

Our teaching improvement plan also hopes to introduce the virtual microscopy system using virtual slides to dental students and further to evaluate their acceptance rates and changes of histopathological diagnosis ability comparing with the glass slide learning for the oral pathology laboratory course. The virtual slides provide good-quality histopathological images without color-fading problem as that in glass slides. In addition, students can freely review the virtual slides by using free image processing software at any time and any place with broadband internet available after class. The results of our study indicate a significantly higher acceptance rate (all \(P\)-values < 0.001) and a significantly better histopathological diagnosis ability (\(P < 0.01\)) in dental students using the virtual slide learning than in dental students using the traditional glass slide learning. Another study also showed the same results that dental students rated all aspects of web-based study in oral pathology laboratory course as highly useful. In addition, students’ satisfaction with the virtual laboratory was high, suggesting that the dental students like virtual microscopy more than traditional optical microscopy for learning the oral histopathology. The previous study concluded that the students appear to enjoy web-based study, and virtual microscopy has significant advantages over real microscopy in oral and maxillofacial histopathological education.

Moreover, the results of the present study also indicate that the virtual microscopy enables oral histopathological learning become time-efficient, user-friendly, convenient, helpful, easy, and interesting.

Compared with traditional glass slide learning, the virtual slide learning increase students’ interest in learning oral histopathology, and their histopathological diagnosis ability improved significantly. The advantage of the virtual

Figure 1  The number of students who answered to the following 7 questions after finishing the learning of oral pathology laboratory course using either traditional glass slides or digitalized virtual slides.
manifestations of oral and maxillofacial diseases to the final diagnosis and treatment of the patients. The future trend of the learning of oral pathology and diagnosis is to set a learning platform that integrate clinical information, radiographic features, and virtual microscopic images of the oral disease cases together, so that not only students but also general practicing dentists can review the cases with complete information, and know how to reach a final diagnose and how to carry out the precise treatment for the patients. We expect that the use of this integrated platform through the internet may increase students’ interest in learning oral pathology and diagnosis, and may improve their overall diagnostic ability of oral and maxillofacial diseases.

Furthermore, during the COVID-19 pandemic, many dental schools have been locked down. Thus, the majority of the lectures in dental schools are switched to the online mode to keep on the learning progress of relevant courses for their dental students. The virtual microscopy system can be performed online to give the oral pathology laboratory course, which also highlights its importance under the COVID-19 pandemic.

Based on the results of this study, we plan to gradually transform all the glass slides into digitalized virtual slides. We also try to integrate the virtual microscopic images and clinical information of oral disease cases together to further establish an integrated online oral pathology and oral diagnosis learning platform in the future. We believe that the virtual slides can gradually replace the glass slides in the learning of oral pathology laboratory course. Furthermore, the virtual slides can even be used by pathologists to sign out the pathological reports for routine surgical pathology specimens at home or at any other places with broadband internet available. We foresee that the virtual microscopic images of the patients’ surgical pathology specimens may be added in the patients’ digital medical charts in addition to the images of computerized tomography, magnetic resonance imaging, and sonography in the future.

**Declaration of competing interest**

The authors have no conflicts of interest relevant to this article.
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