Academic Achievement and Perception of Two Teaching Methods in Histology: Light Microscopy and Digital Systems

Rendimiento Académico y Percepción de dos Métodos de Enseñanza en Histología: Microscopía Óptica y Sistema Digital

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SUMMARY: With the advent of digital systems, the role of the microscope as an irreplaceable instrument in the practical teaching of histology has been called into question. In this study academic performance and student perception for three learning methods was compared: digital systems, microscopy, and microscopy plus digital systems, in the muscle tissue unit of the morphology course for first-year dentistry at the Universidad de los Andes, Santiago, Chile. Ninety-five students were divided into 3 groups: Group 1: individual optical microscopy, Group 2: digital systems (one projector per room), and Group 3: microscopy plus digital systems. All participants observed the same striate muscle, cardiac striated muscle, and smooth muscle mounts. Their diagnostic capacity was evaluated. A perception test was conducted after everyone had learned with both systems. For data analysis the Kruskal-Wallis test and logistic regression were used. In the cognitive evaluation, the median grades were 4.5 for group 2 and 5.45 for group 3 (Kruskal-Wallis p-value= 0.0023). In the perception survey, 69% of students reported feeling motivated by the use of the microscope and 51% reported that they felt motivated by the use of digital system (p-value= 0.0016). It was concluded that the combined use of optical microscopy and digital systems achieves better performance as compared to the digital system alone. The use of the microscope improves student perception as compared to those using only the digital system.

KEY WORDS: Medical education; Histology; Visual learning; Virtual slides; Microscopy.

INTRODUCTION

Curriculum reform in medical schools has focused on reducing the number of contact hours, in order to thin out crowded programs, as well as increasing the emphasis on independent learning, the development of interpersonal skills, and problem solving (Kumar *et al.*, 2006).

Histology has been a longstanding basic science course in medical school curricula worldwide. Traditionally, the light microscope has played a major role in student education, and since the 19th century it has been the best tool for teaching and learning histology (Cotter, 2001). But there are a few problems with it, such as: issues with procurement and costly maintenance of microscopes and stained tissues mounted on glass slides, not all sectioned tissues demonstrate all of the structures that should be identified during laboratory study, and finally due to the pressure to reduce curriculum density and time spent in laboratories (Weaker, & Herbert, 2009).

Today, new technologies are expanding opportunities by casting a wider net in health science learning. Interactive CD-ROMs and the Internet with multimedia have made it possible for personal computers to provide a learning environment similar to that of conventional time-consuming one-on-one tutorial methods (Farah & Maybury, 2009; Harris *et al.*, 2001; Trelease *et al.*, 2000).

Various digital systems are now available for teaching histology. First, those that incorporate static images, such as slide projections, virtual laboratories on CD-ROM, web pages, and Computer-Assisted Instruction (CAI) where students learn by themselves guided by the program sites (Lei *et al.*, 2005; Michaels *et al.*, 2005; Blake *et al.*, 2003; Bloodwood & Ogilvie, 2006). For years researchers have attempted to compare the effects of medical CAI with traditional media (lectures, laboratory experiences, textbooks), but they are usually difficult to perform properly

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because variables such as differences in pedagogical techniques, differences in informational content, and the novelty factor have commonly not been controlled adequately (Lei *et al.*). Secondly, the Virtual Microscope (VM), which is an emerging technology that uses software to allow digital images to be viewed as if they were being viewed using a light microscope (Weaker & Herbert; Krippendorf & Lough, 2005). The latter technology is not widely used, because the initial investment is too expensive, there is a need to have one laptop per student, and a need to purchase the software (Weaker & Herbert).

In the histology area at our university, we conduct theoretical classes, and have light microscopy laboratories, supported by a website created by teachers, so that students can complete the direct hours used in learning this discipline, in their homes.

The aim of this study is to compare academic performance and student perception for three learning methods in the practical teaching of histology: digital system (digital imaging projection), optical microscopy, and a combination of both, in the muscle tissue module of the Histology subject in first year Dentistry at the Universidad de los Andes, Santiago, Chile.

MATERIAL AND METHOD

This paper is an experimental study that has been approved by the Institutional Review Board of the Odontology Faculty of the Universidad de los Andes. It was conducted in order to compare three learning methods in the muscle tissue module of the Histology course. This educational research was analyzed and approved beforehand by the ethics committee of the University.

The study was conducted with 95 students from the first year Dentistry class, who attended the Histology course. Inclusion criteria considered students enrolled in the 2012 course.

The students were divided into three groups by alphabetical order. See the flow diagram of the procedure used (Fig.1).

Group 1: 32 students used microscopy as the learning method, in a room arranged with the same number of light microscopes (Nikon ® YS2 Alphaphot-2, Tokyo, Japan) and a teacher. A television screen was used to indicate the sector of the mounts where the students were to focus their attention. Students were encouraged to ex-

plore the mounts on their own, to search for the previously determined structures.
Working time: Approximately 1 hour

Group 2: 34 students used a digital system in a room arranged with a projector and a teacher. The micrographs used were obtained from the same histological preparations with previously standardized magnification (40X, 100X and 400X). These images were obtained using a microscope (Nikon ® Coolpix 5400, 5.4 megapixels, 4X zoom-Nikkor Lens, USA).
Working time: Approximately 1 hour.

Group 3: consisted of 29 students who used both teaching methods: microscopy and a digital system, in a room arranged with 16 optical microscopes, a television screen, a projector and a teacher.
Working time: 2 hours.

A protocol was drawn up that served as a guide for the teachers of the three groups, in order to unify the criteria for recognition of structures in the various mounts and magnifications used.

At the end of the experimental phase each group took a cognitive test which measured their ability to diagnose the various types of muscle tissue and to identify structures according to the previously proposed objectives, using the following guidelines:

1. Diagnosis of cardiac striated muscle tissue:
a) Intercalated discs, b) Endomysium, c) Muscle fiber.
2. Smooth muscle tissue diagnostic:
a) Muscle fiber, b) Cell nucleus, c) Endomysium
3. Diagnosis of striated skeletal muscle tissue:
a) Muscle fiber, b) Endomysium, c) Perimysium
This evaluation was performed with microphotographs obtained from the samples they looked.

A teacher who was not involved in the practical activities of the unit prepared the cognitive test. The guide teachers had no previous access to this evaluation, which was validated by expert histology teachers, assistants, students of the subject, and other teachers of other subjects.

Finally, an anonymous perception survey was applied to all groups in order to determine how the students felt about the learning systems they used. The perception survey was conducted with a Likert scale consisting of 8 questions with 5 options, ranging from strongly disagree to strongly agree, and a comment section which was also validated by other teachers and students in other years of the course. The questions were:

1. Was muscle tissue learning facilitated by using a microscope?
2. Were you able to properly locate the structures using a microscope?
3. Did you feel comfortable using a microscope?
4. Were you motivated by using a microscope?
5. Was muscle tissue learning facilitated by using the digital system?
6. Were you able to properly locate the structures using the digital system?
7. Did you feel comfortable using the digital system?
8. Were you motivated by using the digital system?

Statistical Analysis. Nominal and ordinal variables were described with absolute frequencies and percentages. The continuous variables were described with central tendency measures, dispersion, and position. For the analysis of the data obtained from both tests we used the Kruskall - Wallis test and a logistic regression model, with the Odds Ratio (OR) report and their 95% confidence interval and p-value.

RESULTS

From a total of 95 students, 30 (32.26%) were in group 1, which had only microscopy learning activities, 34 (36.56%) were in group 2, which had only the digital system and 29 (31.18%) were in Group 3, which combined both methodologies (Fig. 1).

The distribution of students in terms of quantity and type (baccalaureate and repeaters) was homogeneous (data not shown).

The distribution of students with correct identification of tissues and structures by group is shown in Table I Median scores were 5.03, 4.5, and 5.45 for groups 1, 2 and 3, respectively, on a scale of 1 to 7 (where 7 is the highest score), and 3.95 is the failing score. Minimum scores were 2.75, 1.1, and 3.25 for groups 1, 2 and 3 respectively. The group that used both systems had significantly higher scores
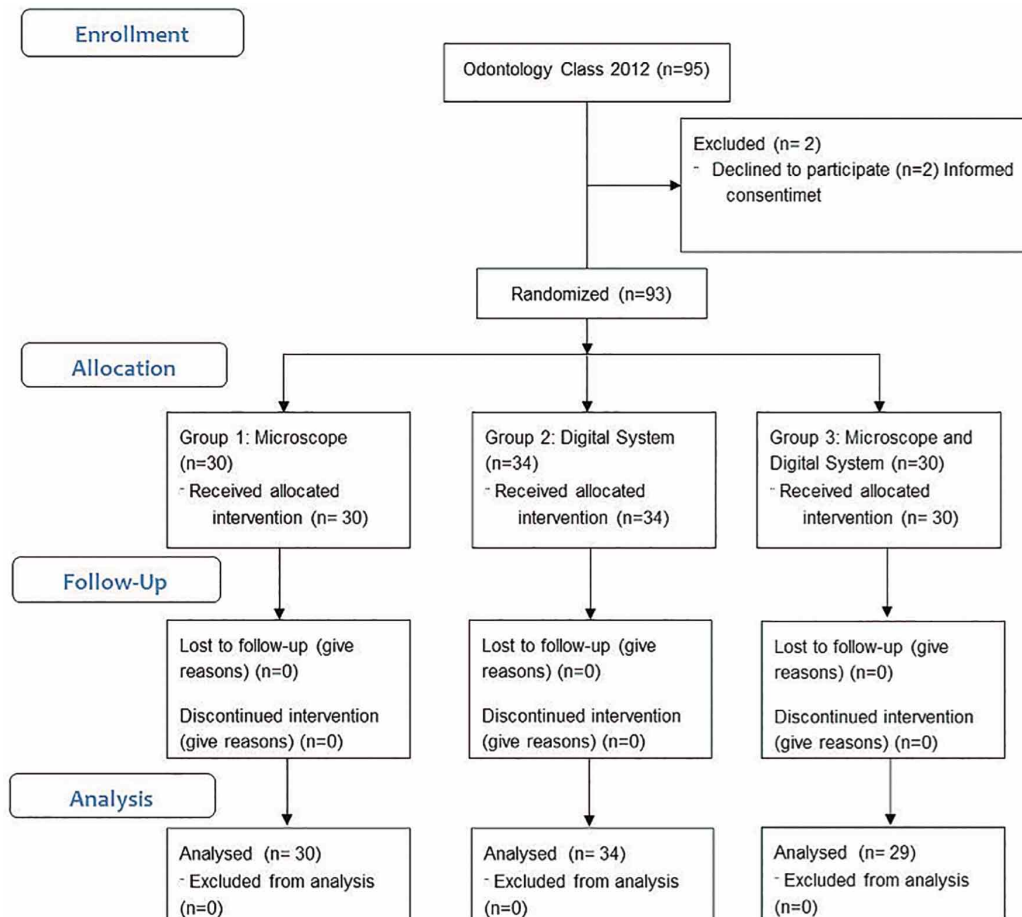

Fig. 1. Flow diagram of the subject enrollment.

Table I. Distribution of students with correct identification of tissues and structures.

	Microscope	Digital	Both
	n= 30 (32.3%)	n= 34 (36.5%)	n= 29 (31.2%)
Cardiac muscle	22 (73.3%)	26 (76.5%)	27 (76.5%)
Intercalated discs	11 (36.7%)	7 (20.6%)	6 (20.7%)
Endomysium	17 (56.7%)	19 (58.8%)	26 (89.7%)
Muscle fibers	17 (56.7%)	20 (58.8%)	24 (82.8%)
Smooth muscle	22 (73.3%)	27 (79.4%)	28 (96.6%)
Muscle fibers	19 (63.3%)	24 (70.6%)	25 (86.2%)
Nucleus	17 (56.7%)	20 (58.8%)	23 (79.3%)
Endomysium	12 (40.0%)	14 (41.2%)	23 (79.3%)
Skeletal Muscle	27 (90.0%)	26 (79.5%)	22 (75.9%)
Muscle fibers	25 (83.3%)	23 (67.7%)	20 (68.9%)
Endomysium	28 (93.3%)	22 (64.7%)	24 (82.8%)
Perimysium	29 (96.7%)	21 (61.8%)	23 (79.3%)

than the group that used only the digital system (Kruskal-Wallis p-value= 0.0023) (Fig. 2).
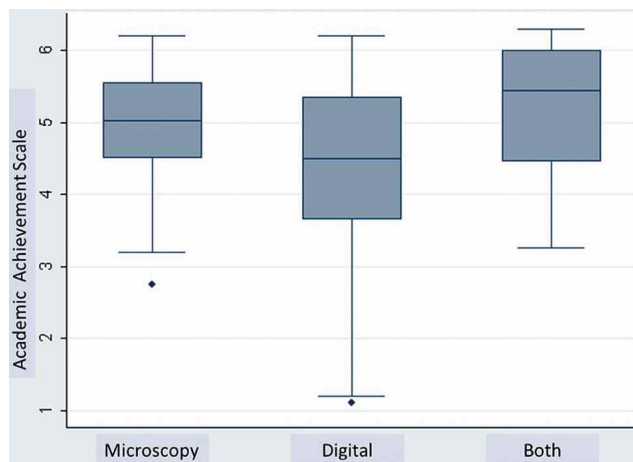

Fig. 2. Academic achievement graphic.

The odds ratios with their respective confidence intervals for correct recognition of tissues and structures can be seen in (Fig. 3).

In the perception survey, 69% of students reported feeling motivated by the use of the microscope and 51% reported that they felt motivated with the use of the digital system (p-value= 0.0016).

Finally, it is noted that there was a decreased percent of satisfaction for those subjects who used both methods together (group 3) with respect to those who used either of the two individual methods (groups 1 and 2), in relation to the question of whether learning was facilitated using the digital system (p-value= 0.015).
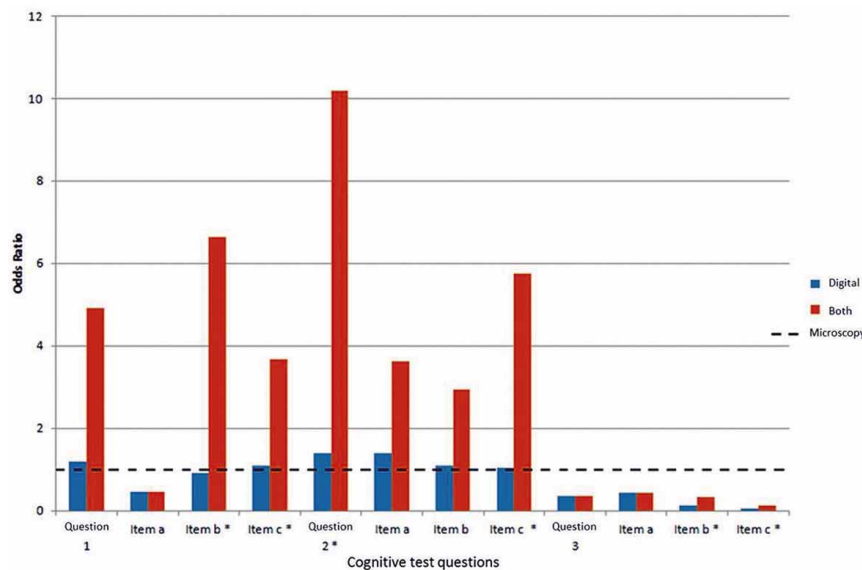

Fig. 3. Odds Ratio graphic of digital group and the group that used digital system and microscopy compared with the microscopy group. *Statistical Difference.

DISCUSSION

In this experimental study the academic performance and perception of dentistry students in the histology course that used optical microscopy as the sole method of learning muscle tissue histology, is compared with those using digital or both methods combined.

The student's distribution in terms of quantity and type (regular, baccalaureate, and repeaters) was homogeneous, and thus it did not influence the performance and perception results.

According to the results by group, the group that studied with both methods combined had a greater percentage of correct answers, both for diagnosis and for identification of tissue structures in cardiac and smooth muscle. This is an agreement with the study by Michaels *et al*. which concluded that a digital system based on still images is only a complement to microscopy study.

The group using only optical microscopy obtained a higher percentage of correct answers in the identification of intercalated disks in cardiac muscle and multinucleated fiber cell, endomysium and perimysium in skeletal muscle. This may be due to the fact that light microscope encourages students to do a personal search of structures, as Lei *et al*., established in their study where the individual identification of structures by the students appears as the best learning strategy.

In our study, statistically significant differences were observed when comparing the final score obtained by groups 3 and 2 (Grades Median: 5.45 vs. 4.5). In the logistic regression of the association between groups and correct answers, there was also a significant difference between groups 2 and 3. This again supports the idea that the combined use of both methods improves performance, as has been stated by Michaels *et al*., who further stated that the sole use of a digital system in which students receive information passively has lower performance. This contrasts with some studies (Cotter, 1997; Rosenberg *et al*., 2006) that describe how CAI could replace microscopes, saying that they are just as effective, considering that this method requires students to study actively. However, in their study Lei *et al*., concluded that most CAI tools are limited by static images that do not replicate the interactive function of the microscope (Krippendorf & Lough; Lei *et al*.).

This study also compared the perception of students who used light microscopy as a method for the practical teaching of muscle tissue histology, against those who used digital alone or both methods combined. In the perception survey 73.6% claim to have been motivated by the use of the microscope versus 51% with the digital system. As has been described in literature, it has been difficult to replace the light microscope with digital systems, since there is a perception that histological images are best read with microscopy (Lei *et al*.). Our results also contrast with other studies that conclude that the interactive methodologies were better perceived than light microscope (Rojas *et al*., 1999; Rosas *et al*., 2012).

Finally, it should be noted that, although the combined system obtained higher percentage of correct answers, it is necessary to consider that this group had two hours of practical work, whereas the individual methods had only worked one hour each. The differences in time spent could have influenced this outcome, which should be considered for future experiences. However, Elizondo-Omaña *et al*. (2004) reported that there is no evidence that the number of hours of study influence academic performance.

Krippendorf & Lough reported in their study that faculty members were surprised that students had learned less with the CAI system, and abandoned this method in order to return to light microscopy. This is consistent with what we observed: static images should not be used by themselves, but to support the light microscope.

Finally our faculty wishes to make it clear that we are not against implementing high-cost virtual microscopy, since it is clear that this system helps reduce teaching hours and also reduces the cost of maintaining and purchasing microscope histological mounts. Besides, there are no significant differences in student performance compared with the light microscope, a situation that did occur when comparing static digital systems with light microscopy (Weaker & Herbert).

In conclusion the results were significantly higher in the group that used both methods combined, especially when compared to the group using the digital system alone. The exclusive use of microscopes improves the perception of students, compared with the use of only the digital system.

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RESUMEN: Con el advenimiento de los sistemas digitales, se ha puesto en tela de juicio el rol del microscopio como instrumento insustituible para la enseñanza práctica de la histología. El objetivo fue comparar el rendimiento académico y la percepción de los alumnos utilizando tres métodos de aprendizaje: sistema digital, microscopía y microscopía más sistema digital, en la unidad de tejido muscular del curso de morfología de primer año de Odontología de la Universidad de los Andes. Noventa y cinco alumnos fueron divididos en 3 grupos: 1: microscopía óptica individual, 2: sistema digital (proyección única en sala) y 3: microscopía más sistema digital. Todos observaron los mismos preparados de músculo estriado esquelético, estriado cardiaco y liso. Al finalizar, rindieron una evaluación cognitiva y luego los grupos fueron invertidos. Una vez que todos aprendieron con ambos sistemas realizaron una encuesta de percepción. Para el análisis de datos se utilizaron los test de Kruskall-wallis y Regresión Logística. En la evaluación cognitiva, el grupo 3 resultó ser significativamente superior a las del grupo 2 (Kruskall-wallis P= 0,0023). En la encuesta de percepción el 69% de los alumnos expresaron sentirse motivados por el uso del microscopio y un 51% respondieron que se sintieron motivados con el uso de sistema digital (p= 0,0016). En conclusión, el uso combinado de microscopía más sistema digital obtuvo mejores resultados que el sistema digital solo, y el uso de microscopio obtuvo una mejor percepción comparada entre quienes usaron únicamente el sistema digital.

PALABRAS CLAVE: Educación médica; Histología; Aprendizaje visual; Diapositivas virtuales; Microscopía.

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