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Theoretical knowledge versus practical performance in dental carving: preliminary study

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ABSTRACT | Knowledge of tooth anatomy is essential to practicing the various dental specialties. All dental schools must have a discipline responsible for teaching dental anatomy in their curriculum, in which theoretical content is conveyed to students and later reproduced by them in dental carving wax. Thus, the aim of this study was to assess whether the theoretical content taught in the Discipline of Dental Sculpture of the Department of Restorative Dentistry, School of Dentistry, University of São Paulo, is related to the students' performance in carving practice. For this purpose, 76 theoretical exams (planned on the location of the anatomical features of the maxillary left canine tooth), and 76 wax sculptures (practical exam) were individually examined by two previously trained examiners for each trait. The data were organized in tables according to the characteristic analyzed and the type of exam (theoretical or practical). The chi-square test showed no statistically significant difference between theoretical and practical exams ($p \geq 0.05$). The tooth structure that students most answered correctly in both exams was the cingulum (79%) and the greatest shortcoming of students in associating both exams was the location of the palatine cervical bulge (19%). The findings are based only on results of student performance with regard to the identification and location of anatomical structures on one anterior tooth. Considering the data obtained, it was concluded that it was not possible to observe a relationship between the theoretical knowledge acquired by the students and their practical performance in tooth carving.

DESCRIPTORS | Sculpture; Teaching; Tooth Components; Tooth / anatomy & histology.

RESUMO | **Conhecimento teórico versus performance prática em escultura dental – estudo preliminar** • Conhecer a anatomia dos dentes é de fundamental importância na prática das diversas especialidades odontológicas. Todas as faculdades de odontologia possuem obrigatoriamente em sua grade curricular uma disciplina responsável pelo ensino da anatomia dental, na qual um conteúdo teórico é transmitido aos alunos para reprodução na escultura em cera. Assim, o objetivo deste estudo foi avaliar se o conteúdo teórico programático ministrado na Disciplina de Escultura Dental do Departamento de Dentística da Faculdade de Odontologia da Universidade de São Paulo está relacionado com a performance dos alunos na escultura prática. Para isso, 76 provas teóricas, planejadas sobre a localização das características anatômicas do dente 23, e 76 esculturas em cera (prova prática) foram examinadas individualmente por dois examinadores pré-calibrados para cada característica selecionada. Os dados foram organizados em tabelas de acordo com as características analisadas e o tipo de exame (teórico ou prático). O teste de qui-quadrado apontou que não houve diferença estatisticamente significativa entre as provas teórica e prática ($p \geq 0.05$). A estrutura dental que os alunos mais acertaram em ambas as provas foi o cíngulo (79%) e a de menor porcentagem de acerto na associação das 2 provas foi a bossa palatina (19%). Os achados são baseados somente nos resultados do desempenho dos alunos com relação à identificação e localização das estruturas anatômicas de um dente anterior. Dentro das limitações deste estudo, concluiu-se que, para os dados avaliados, não foi possível observar uma relação entre os conhecimentos teóricos adquiridos pelos alunos e seu desempenho prático na escultura.

DESCRITORES | Escultura; Ensino; Componentes do Dente; Dente / anatomia & histologia.

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INTRODUCTION

The dentist is the professional committed to restoring and/or replacing lost tooth structure, and, when necessary, aesthetics. A good dental practice involves a combination of theoretical foundational knowledge and psychomotor skills components. However, a great challenge for dental schools has been the development of students' manual skills.

The discipline of Dental Morphology and Sculpture is one of the first dental disciplines found in many curriculums in order to introduce this topic in the early stage of the program. It aims to teach the complex aspects of the primary and permanent dentitions, developing and training the students' manual skills, in order to prepare them for the following disciplines and clinical activities that will also require this ability.[1]

Traditional ways of teaching psychomotor skills in the dental anatomy curriculum may include exercises like line drawings and teeth carving out of wax blocks.[2]

Motor learning involves changes in an individual's internal processes that determine the person's ability to perform a motor task.[3] At the early stages of learning, the lack of spatial vision is what hinders the construction of a tooth. Within this context, a commonly used method in schools is the geometrical method of dental carving that helps students in practical training by comparing the tooth's anatomical shape to geometric figures.

This method of dental sculpture was first cited by Wheeler[4] in 1940 and later improved by other authors.[5] It consists of the projection of a tooth outline on a wax block and, subsequently, on the definition of anatomical structures. Tooth shape can be very difficult for students to perceive, so the association with geometric figures is considered to be useful in the teaching process. Students know geometric figures since childhood, so the observation of this relationship makes the process of learning tooth morphology easier. The main concern was whether wax sculptured by geometric methods leads students to a mechanical process devoid of a theoretical evolution of knowledge.

The aim of this study was to evaluate if there is a relationship between theoretical knowledge acquired by undergraduate students of the Discipline of Dental Sculpture of the School of Dentistry, University of São Paulo, and the application of this information in a three-dimensional wax sculpture.

MATERIAL AND METHODS

This study assessed the knowledge of the anatomy of the maxillary left canine tooth held by seventy-six undergraduate students enrolled in the discipline of Dental Sculpture of the School of Dentistry, University of São Paulo.

Prior to exams, the students attended a series of 4 lectures (totalling approximately 16 hours) detailing the anatomy of each group of teeth from the adult dentition and the carving technique through the geometric method.[5] The lectures detailed the anatomical features of each tooth, including the maxillary left canine tooth, in a two-dimensional slide-show. After each theoretical lecture, the students were able to practice the carving technique by carving the tooth features learned in a wax block.

Seventy-six theoretical exams of these students were evaluated and compared with their practical exams.

Theoretical exam

The theoretical exam consisted of concepts and indicating the location of the anatomical structures of the maxillary left canine tooth.

Practical exam

The practical exam consisted of carving the maxillary left canine tooth in a wax block (48 mm in height, 22 mm in width and 19 mm in depth) using the geometric method[5] previously detailed in the given lecture. The following anatomical char-

Table 1 | Anatomical characteristics evaluated with p values, X^2 and percentage of correct answers on theoretical and practical exams.

Anatomical characteristics	YY	YN	NY	NN
Crown-root angle (p = 0.82, X^2 = 0.048)	29 (38%)	33 (44%)	7 (9%)	7 (9%)
Buccal cervical bulge (p = 0.50, X^2 = 0.44)	21(28%)	1 (1%)	53 (70%)	1 (1%)
Palatine cervical bulge (p = 0.17, X^2 = 1.85)	15 (19%)	2 (3%)	57 (75%)	2 (3%)
Mesial cervical bulge (p = 0.18, X^2 = 1.72)	46 (60%)	3 (4%)	27 (36%)	0
Distal cervical bulge (p = 0.34, X^2 = 0.89)	51 (67%)	2 (3%)	23 (30%)	0
Buccolingual convergence of the proximal surfaces (p = 0.44, X^2 = 0.57)	35 (46%)	17 (22%)	14 (19%)	10 (13%)
Cervicoincisal convergence of the proximal surfaces (p = 0.15, X^2 = 2.06)	51 (67%)	0	24 (32%)	1 (1%)
Cingulum location (p = 0.47, X^2 = 0.50)	60 (79%)	2 (3%)	13 (17%)	1 (1%)

YY = Answered correctly in theory and practice, YN = Answered correctly in theory and incorrectly in practice, NY = Answered incorrectly in theory and correctly in practice, NN = Answered incorrectly in theory and in practice.

acteristics were considered for evaluation in this study:

- crown-root angle,
- buccal cervical bulge (the most prominent region of the buccal survey line),
- palatine cervical bulge,
- mesial cervical bulge,
- distal cervical bulge,
- buccolingual convergence of the proximal surfaces,
- cervicoincisal convergence of the proximal surfaces, and
- cingulum (Table 1).

Two previously trained independent examiners analyzed the anatomical structures in order to standardize the data tabulation. The success survey of each student was performed individually for both theoretical and practical exams and referred to the characteristics and location of anatomical structures. Each student was codified with a number, and a table with the number of each student was constructed in which the anatomical structures evaluated were displayed in the first column, followed by a column for the practical exam evaluation and another for the theoretical exam. Those who answered the theoretical question correctly received a "Y" (yes) in the column corresponding to the structure assessed, whereas when they answered the question incorrectly, an "N" (no) was placed in that column. The same procedure was followed for the structures assessed in the wax carving.

The wax carved teeth were evaluated for the location of the same anatomical structures identified in the theoretical exam. The previously trained examiners evaluated each tooth separately. If there was a disagreement between them, the tooth was re-analyzed and compared with those previously assessed, until a consensus was reached.

The possible associations of theoretical and practical exams for each structure were totaled and listed as:

- YY = Answered correctly in theory and practice,
- YN = Answered correctly in theory and incorrectly in practice,
- NY = Answered incorrectly in theory and correctly in practice,
- NN = Answered incorrectly in theory and in practice (Table 1).

Data were recorded in a Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) spreadsheet according to the characteristics evaluated and individually analyzed using statistical software (SPSS version 12.0 for Windows, IBM Corporation, NY,

USA). The data of the practical exam were compared with those of the theoretical exam using the chi-square test.

RESULTS

In order to show the statistical difference between theoretical and practical exams, the chi-square test in the 2 × 2 contingency table was applied. No statistically significant difference between the results obtained for the theoretical and practical exams was found ($p \geq 0.05$; Table 1).

A comparison between the results of the theoretical test and the performance of students in the dental carving practical exam was performed to evaluate the reproduction of the anatomical structures in the wax sculpture. Statistically, it was not possible to establish a correlation between theoretical knowledge and its practical application, but some remarks can be made.

The dental structure about which students most often answered correctly on both exams, practical and theoretical, was the "cingulum". Two structures had the second highest percentage of success in both practical and theoretical exams:

- the "distal cervical bulge" and
- the "cervicoincisal convergence of the proximal surfaces."

On the other hand, the "palatine cervical bulge" was the structure with the highest percentage of error (YN + NY = 78%) in the theoretical exam and the structure with the lowest percentage (19%) of correct answers in the comparison between theoretical and practical exams (YY). Nevertheless, the percentage of correct answers in the practical exam was high, indicating that students were able to reproduce the tooth's anatomical characteristics in the correct position, but were unable to locate it in the theoretical exam.

The largest percentage of error in the practical exam was the "crown-root angle," where 53% of students (YN + NN) did not carve the structure correctly. However, 82% of students (YY + YN) correctly pointed out this structure in the theoretical exam, indicating that they are often not able to apply the theoretical knowledge in practical carving. On the other hand, for the cingulum, the theoretical knowledge was applied successfully in practice, since 82% (YY + YN) of students correctly located the structure in the theoretical exam and 96% (YY + NY) of them carved it correctly.

Except for the "buccolingual convergence of the proximal surfaces," that presented the highest percentage (13%) of error in the association of theoretical and practical exams (NN), all remaining structures presented a very low percentage of error, showing that the students could retain the knowledge and apply it in the practical and/or theoretical exams.

Only the "crown-root angle" and "buccolingual convergence of the proximal surfaces" presented a high percentage of correct answers in theory and error in practice (YN). For the other structures, the percentage of (NY) was higher showing that even when students did not have the theoretical knowledge, they were able to carve them in the wax block.

DISCUSSION

Owing to the selection process for entry to the school of Dentistry, University of São Paulo, students have similar intellectual knowledge because they are subjected to the same theoretical examinations. However, candidates are not evaluated on their manual skill or dexterity, and one may assume that students have different life experiences leading to different abilities. Although several schools apply a dental admission test as an additional evaluation for student admission, it has been demonstrated that these tests cannot predict students' manual ability.[6] This is because practice during the dentistry course leads to improvement of students' manual dexterity.[1,7]

Tooth morphology knowledge, in all its details, is very important for a dentist in daily dental practice. Siéssere *et al.*[8] reported that the theoretical study of dental anatomy alone is not sufficient for dentists, and practical knowledge of tooth structures is essential. Thus, dental wax carving is considered an important resource in the acquisition and retention of knowledge about dental anatomy.

Dental carving is a relevant discipline for training dentists, since it allows students to develop their manual dexterity and provides knowledge on dental anatomy. Indeed, Polyzois *et al.*[7] demonstrated in their study that preclinical training may result in a significant improvement of the student's manual skills, and Kilistoff[9] showed that both amalgam and composite restorations could be performed quickly and accurately using the systematic technique of sculpture.

In this study, the authors compared the results of the theoretical test with the students' performance in the dental sculpture exam in order to access the practical reproduction of the anatomical structures in the wax sculpture.

Interestingly, after analysis of the statistical data, it was not possible to establish a correlation between theoretical knowledge and its practical application. Excluding the structures that were identified correctly or incorrectly in theory and practice (YY and NN), most of the structures evaluated presented a high percentage of error in the theoretical exam and correct answers in the practical exam (NY) showing that even when students did not have the theoretical knowledge of dental structures, they were able to carve them in the wax block. One can explain this by the geometric method applied in this study. Somehow, it directs the student to a geometric shape close to the final stage of the sculpture, in which the student forms the overall shape of his/her sculpture, then applies his/her theoretical knowledge.

The dental structure that students most answered correctly on both exams (YY), practical and theoretical, was the "cingulum" (79%). The cingulum of the upper canine is large and characteristic of this dental element.[10] The choice of tooth 23 for this preliminary assessment was due to the fact that, even though it is an anterior tooth, the canine presents characteristics of posterior teeth, called by some authors as "cusp".

Despite being one of the oldest methods, the geometric method applied in this study is still valuable and should be combined with other teaching techniques. Studies have shown that students learn equally well by both traditional and the most innovative methods.[11-13]

Advances in communication technology offer innovations that aid in the teaching of students to develop new skills or new information.[14-16] Gal *et al.*[14] tested a haptic simulator for training and practicing manual dexterity in dentistry. The authors found the simulator to have significant potential benefits in teaching manual skills.

Nance *et al.*[13] developed a study to determine the equivalence of computer-assisted instruction (CAI) to traditional laboratory instruction in the area of dental anatomy wax carving. There was no statistical difference between carving grades between the two groups. According to the authors, students' learning needs may be best met by merging CAI with traditional laboratory teaching.

Mitov et al.[15] created a multimedia instrument, based upon virtual reality technologies, which allows the reproduction of realistic 3D anatomical models of human teeth via the Internet, thus providing dental students with a useful tool supporting the traditional teaching of dental anatomy. For three semesters, the assessment module was applied as a test method in parallel with the traditional tooth anatomy exam. There was no statistical difference between the results of the two examination methods. These results are in accordance with those reported by Bogacki *et al.*,[11] who tested the equivalence of computer-assisted learning and tra-

ditional teaching of dental anatomy, and the results showed equivalence.

A greater understanding of student learning difficulties for each tooth structure will be valuable in developing educational materials and classes more focused on the most difficult characteristics, minimizing the difficulties of students.[17, 18]

CONCLUSION

Within the limitations of this study, it was concluded that there is no relationship between students' knowledge obtained through lectures and its application in the practical training of tooth sculpture.

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