



CLINICAL RESEARCH:

Evaluation of the Effect of Carving Materials Used in Dental Anatomy Courses on Students' Preferences and Performance

Evaluación del efecto de materiales de tallado utilizados en los cursos de anatomía dental en el desempeño y preferencias de los estudiantes

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ABSTRACT: Training in dental carving has played an important role in the education of dental students by developing their manual skills and preparing them for other areas of knowledge that require these skills. This study aimed to evaluate students' performance with different carving materials used in dental anatomy courses and their opinions on these materials. 124 first-year preclinical students participated in this study. They prepared cube blocks of plaster, wax, and soap. From each block they carved a sphere of 2 cm diameter. They were given one hour for each material. At the end of the period, the works were collected. After the carving was completed, a 5-question survey was given to the students to find out their thoughts. The works were graded by three prosthodontists. The grades were compared statistically and the students' opinions were evaluated. The wax work had the highest mean, and this difference was significant. The mean of the plaster work was the lowest. These marks were directly proportional to the students' thoughts. Most of the students wanted the carving material used in the courses to be wax, and a few of them wanted it to be plaster. The students liked working with wax the most and performed best when working with wax. They found the plaster carving the most difficult and performed the worst.

KEYWORDS: Dental anatomy; Dental education; Dental students; Training and carving.



RESUMEN: El entrenamiento en el tallado dental ha desempeñado un papel importante en la formación de los estudiantes de odontología, al desarrollar sus habilidades manuales y prepararlos para otras áreas del conocimiento que requieren dichas destrezas. El objetivo de este estudio fue evaluar el desempeño de los estudiantes al utilizar diferentes materiales de tallado empleados en los cursos de anatomía dental, así como sus opiniones respecto a dichos materiales. En este estudio participaron 124 estudiantes preclínicos de primer año. Los participantes prepararon bloques cúbicos de yeso, cera y jabón, a partir de los cuales tallaron una esfera de 2 cm de diámetro. Se asignó un tiempo de una hora para el trabajo con cada material. Al finalizar cada período, los trabajos fueron recolectados. Tras completar el tallado, se aplicó a los estudiantes una encuesta de cinco preguntas para conocer sus percepciones. Los trabajos fueron evaluados por tres prostodoncistas. Las calificaciones se compararon estadísticamente y se analizaron las opiniones de los estudiantes. Los trabajos realizados en cera presentaron el promedio más alto, siendo esta diferencia estadísticamente significativa. El promedio más bajo correspondió a los trabajos en yeso. Estas calificaciones fueron directamente proporcionales a las percepciones expresadas por los estudiantes. La mayoría de los participantes manifestó su preferencia por que el material de tallado utilizado en los cursos fuera la cera, mientras que solo un pequeño número indicó preferir el yeso. Los estudiantes mostraron una mayor preferencia por trabajar con cera y obtuvieron su mejor desempeño al utilizar este material. Por el contrario, consideraron el tallado en yeso como el más difícil y presentaron el desempeño más bajo.

PALABRAS CLAVE: Anatomía dental; Educación odontológica; Estudiantes de odontología; Entrenamiento y tallado.

INTRODUCTION

It is very important to have a good knowledge of dental anatomy in clinical practice because it is the basis of dentistry (1,2). To ensure that dental restorations look as natural as possible, anatomical details must be reproduced. Restoring function and aesthetics involves many processes that require artistic understanding, manual dexterity, and professional skills as well as technical knowledge (3,4). Dental anatomy plays a very important role in the dentistry curriculum. Methods of teaching dental anatomy include lectures, drawing teeth, and carving teeth from models (5,6). Carving has been suggested to develop cognitive and motor skills (7), using wax, plaster (8), and soap block. These materials are used due to their relatively low cost and ease of use (9). Previous studies have demonstrated the importance of dental anatomy

carving training and assessment for the clinical performance of dental students. Teaching of dental anatomy and carving varies considerably from school to school, often depending on previous experience and tradition (10).

In this era, students will have a more efficient and enjoyable e-learning experience as they are curious about technology and more familiar with the latest equipment. These computer-based methods make it easier to absorb information because they provide excellent visualisation using virtual anatomy. These techniques can be used as complementary teaching methods to make learning more interesting and clinically meaningful. However, wax carving remains the gold standard when compared to e-learning techniques. Wax carving remains the most widely used method for teaching dental morphology in schools worldwide (1).

The aim of this study is to compare the effects of carving materials used in the dental anatomy course on students' performance and to evaluate students' thoughts about these materials.

METHODS

This study was approved by the Ethics Committee of Institutional Review Board under reference number 2024/5587. 124 first-year students participated in the study (71 female, 53 male). At the beginning of the fall semester of the first year of the faculty of dentistry, plaster mixing and wax folding demonstrations were held in the laboratory sessions of the dental anatomy course. As it was the beginning of the semester, none of the students had carved before. Therefore, the students had the same level of knowledge and skill with all materials. Before the carving period began, all students prepared the blocks they would carve from plaster, wax and soap (Figure 1). The students were asked to carve a sphere with a diameter of 2 cm (Figure 2). One hour was given for each material. The order in which students carved the three materials (wax, plaster, and soap) was randomized for each participant to minimize potential learning effects. Once all the work had been collected, it was assessed by three prosthodontists using a double-blind method. Four criteria were self-assessed and scored: accuracy, finish, size and symmetry. The criteria were graded as "poor," "satisfactory," and "ideal". A numerical score was given for each grade: '1' for poor, '3' for satisfactory and '5' for ideal. After the carving was completed, a 5-question survey was distributed to the students to find out their thoughts.



Figure 1. Cubes prepared for carving; wax, plaster, soap (from left to right).



Figure 2. Spheres made by carving; wax, plaster, soap (from left to right).

Categorical variables were expressed as numbers and percentages, whereas continuous variables were summarized as median and minimum-maximum, where appropriate. Chi-square test was used to compare categorical variables between the groups.

Kendall's coefficient of concordance was used to assess inter-rater agreement. For discrete data, the Kruskal-Wallis test was used to compare more than two groups. The Bonferroni-adjusted Mann-Whitney U test was used to compare multiple groups. P values of <0.05 were considered as statistically significant. Calculations were performed using IBM SPSS Statistics (version 20. IBM Corp. Armonk).

RESULTS

The agreement between the three examiners was examined for the sphere shape made by the students from wax, soap and plaster materials. Kendall's coefficient of concordance (W) was calculated to assess the degree of agreement between the examiners on the ordinal scores. Kendall's W ranges from 0 to 1, with 0 indicating no agreement between the raters and 1 indicating perfect agreement. The Kendall's coefficient of concordance for wax was only 0.658, indicating a moderate agreement between examiners. The inter-rater agreement coefficients for soap and plaster were 0.911 and 0.928 respectively. This shows that there is a perfect agreement (Table 1).

Since there is agreement between the assessors, the scores given to the materials by a random

assessor can be examined. In this study, however, the material comparisons of three examiners were analysed separately. In this respect, the order of use is wax, soap and plaster to better make the same shape (Table 2).

The students scored highest on wax, then soap, and lowest on plaster. The difference between these scores was found to be statistically significant.

Table 3 shows the students' responses to the 5-question survey and their percentages. According to this table, most of the students liked carving and thought that it was useful for learning dental anatomy. More than half of the students liked working with wax, a few did not like any material at all. Most students (66,9%) found it very difficult to work with plaster. While 41.9% found the time to work with wax sufficient, 30.6% found the time to work with none of the materials sufficient.

A chi-square test was performed to assess the relationship between gender and perceptions of which material is easy to work with. The results

showed no statistically significant association ($p=0.220$). A proportional difference was observed in the responses to the question. For instance, 52.1% of females and 50.9% of males selected "Wax", while the opposite was true for "Soap", with 36.6% of females and 26.4% of males choosing it. However, these differences were not significant, indicating that responses regarding ease of working with materials did not differ systematically by gender (Table 4).

Similarly, the chi-square test revealed no statistically significant relationship between gender and responses to which material is hard to work with ($p=0.155$). Distributional patterns indicated that females most frequently identified "Plaster" as difficult (71.8%), followed by "Soap" (12.7%), whereas males also most frequently selected "Plaster" (58.5%) and "Soap" (22.6%). Although these proportions suggest some variation across gender groups, the differences were not statistically meaningful, implying that perceptions of material difficulty were comparable between males and females (Table 4).

Table 1. Kendall's coefficient of concordance for scores between examiners.

Material	W	p
Wax	0.658	<0.001
Soap	0.911	<0.001
Plaster	0.928	<0.001

W:Kendall's Coefficient of Concordance.

Table 2. Comparison of scores for works made from three materials.

Examiner	Material			p	Pairwise Comparision		
	Wax	Soap	Plaster		Wax-Soap	Wax-Plaster	Soap-Plaster
I	5(3-5)	4(3-5)	3(1-4)	<0.001	<0.001	<0.001	<0.001
II	5(4-5)	4(3-5)	3(1-5)	<0.001	<0.001	<0.001	<0.001
III	5(3-5)	4(3-5)	3(1-4)	<0.001	<0.001	<0.001	<0.001

The data are summarized as median(minimum-maximum).

Table 3. Surveys questions and evaluation results.

Questions	Response	Frequency (Percent)
Did you like carving?	Yes	78(62.9)
	No	34(27.4)
	No sure	12(9.7)
Do you think carving will be useful in recognizing the morphological features of teeth?	Yes	69(55.7)
	No	48(38.7)
	No sure	7(5.6)
Which material is easy to work with?	Wax	64(51.6)
	Soap	40(32.2)
	Plaster	12(9.7)
	None	3(2.4)
	All	5(4.0)
Which material is hard to work with?	Wax	13(10.4)
	Soap	21(16.9)
	Plaster	82(66.1)
	None	5(4.0)
	All	3(2.4)
For which was the time most comfortable?	Wax	52(41.9)
	Soap	31(25.0)
	Plaster	1(0.8)
	None	38(30.6)
	All	2(1.6)

Table 4. The chi-square test of the relationship between gender and perceptions.

	Response	Gender		p
		Female	Male	
Which material is easy to work with?	Wax	37(52.1)	27(50.9)	0.220
	Soap	26(36.6)	14(26.4)	
	Plaster	6(8.5)	6(11.3)	
	None	0(0)	3(5.7)	
	All	2(2.8)	3(5.7)	
Which material is hard to work with?	Wax	5(7)	8(15.1)	0.155
	Soap	9(12.7)	12(22.6)	
	Plaster	51(71.8)	31(58.5)	
	None	3(4.2)	2(3.8)	
	All	3(4.2)	0(0)	

DISCUSSION

Technological advances in recent years have made tools such as 3D virtual modelling, stereolithography, virtual reality (VR), and augmented reality (AR) more accessible than ever before (11). As a result, regardless of the simulation system, they practice carving with different materials in practical laboratory courses. Training in dental carving has played an important role in the education of dental students by developing their manual skills and preparing them for other areas of knowledge that require these skills. Each faculty uses wax, soap or plaster as a carving material. In our study, we aimed to find out which of these materials the students were more successful in using and would like to use more. The study was designed and conducted with a sample of first-year students. However, following the implementation of the proposed methodology, the power was calculated using G*power, based on the study findings, and a 99% power rating was obtained.

Nance *et al.* (12) compared the performance of students exposed to two different teaching methods and Bilir *et al.* (13) evaluated the effects of soap carving and digital sculpting on students' performance. In these studies, students carved teeth from soap. In our study, we evaluated the use of the material, not the sculpting technique and the effect of the sculpting on anatomy learning, so we did not have a tooth-shaped sculpture made. It was important that the students were at the same distance from all the materials so as not to influence the results, so we did the study at the beginning of the semester. The students had no knowledge of anatomy, so we asked them to sculpt in the shape of a sphere. Students started working with the material they wanted, thus the learning effect was minimized by randomly determining the order of material use. Dental plaster is used to fabricate preliminary dental cast (study cast) for

a diagnostic purpose and to design the treatment plan. In order to construct indirect restorations outside the mouth such as inlays, onlays, dental crowns, and bridges, a final dental cast or die must first be fabricated (14). The works made of plaster received the lowest scores, probably due to the hardness of the plaster we obtained as a dental cast and it was their least favourite material to work with.

The moderate inter-examiner agreement observed for wax ($W=0.658$) may be explained by its optical characteristics. The pink dental wax used in this study is semi-translucent and has a glossy surface, which reflects light and can mask or exaggerate small surface irregularities and dimension depending on the viewing angle. In addition to translucency and gloss, the pink coloration of wax may have further reduced the visibility of fine details compared with the white and opaque appearance of plaster and soap. While plaster provides a matte, uniform surface that allows examiners to perceive contours more consistently, and soap, although matte, can be polished to improve visual clarity, the combined translucency, gloss, and color properties of wax appear to have introduced greater subjectivity in evaluation. These color- and surface-related differences likely contributed to the higher consistency of assessments for plaster and soap ($W>0.9$) compared with wax. Similar to previous findings emphasizing how translucency, background, and illumination conditions influence visual evaluation of esthetic dental materials (15), the optical properties and inherent color of carving materials should be taken into account when interpreting inter-rater reliability.

We adapted the surveys given to students in some studies (12,13,16-19) to learn about their experiences with dental anatomy and carving for our study. Contrary to the study conducted by Kara *et al.* (18), the students were most successful with

wax and preferred it. This was because they were not afraid of making mistakes and could correct them by adding wax if necessary.

In terms of time, they found it easiest to complete the work with wax, and the reason for this was that they could carve quickly without having to worry about the possibility of correcting it by adding more. If they made a mistake with soap and plaster, the thought of going back to the beginning slowed their progress.

According to the survey, most of the students liked carving. As in most studies (4,9,10,12), they thought that carving was effective for learning. Even though their work in wax received higher scores, they carved well with all materials.

Comparisons with emerging digital carving methods also merit attention. Studies have shown that digital sculpting and virtual tools provide advantages such as enhanced visualization, error correction without material loss, and increased student engagement (11,13). More recently, Maragha & Chehroudi reported (20) that novel digital carving exercises improved structured support and highlighted specific student needs, although they differ substantially from traditional tasks in psychomotor demands. In addition, Hsu *et al.* (21) demonstrated that three-dimensional digital simulation significantly enhances practical skill development in dental morphology, confirming the educational value of digital platforms. Nevertheless, despite these advantages, manual carving with wax, plaster, or soap remains fundamental for cultivating tactile perception and fine motor coordination, which are critical in clinical dentistry. Our findings, showing students' preference and superior performance with wax, are consistent with international reports where traditional materials continue to play a central role in dental anatomy education, complementing rather than replacing digital methods.

CONCLUSIONS

According to the results of this study, most students expressed favorable perceptions of tooth carving and considered it a useful activity for learning dental morphological features. Wax was identified as the preferred carving material, whereas plaster was reported as the least preferred option.

CONFLICT OF INTEREST: The authors declare no conflicts of interest.

ETHICS COMMITTEE: This study was approved by the Ethics Committee of Inonu University by reference number 2024/5587.

AUTHOR CONTRIBUTION STATEMENT: Conceptualization and design: H.Ş.G.; Literature review: H.Ş.G. and M.T.; Methodology and validation: M.T. and N.İ.Ö.; Formal analysis: N.İ.Ö.; Investigation and data collection: H.Ş.G.; Resources: H.Ş.G.; Data analysis and interpretation: N.T.D.; Writing-original draft preparation: H.Ş.G. and M.T.; Writing-review & editing: H.Ş.G. and M.T.; Supervision: H.Ş.G.

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REFERENCES

1. Azevedo R.A., Correa M.B., Torriani M.A., Lund R.G. Optimizing quality of dental carving by preclinical dental students through anatomy theory reinforcement. *Anat Sci Educ* 2018; 11 (4): 377-84.
2. Al-Zain A.O., Abdel-Azim A.M., Othman H.I. Dental students' didactic and psychomotor skills performance in dental anatomy and preclinical operative dentistry courses in a Saudi governmentalschool. *IntJ Dent* 2021; 2021 (1): 8 pages. <https://doi.org/10.1155/2021/7713058>

3. Azevedo R.A., da Rosa W.L.O., da Silva A.F. et al. Comparative Effectiveness of Dental Anatomy Carving Pedagogy: A Systematic Review. *J Dent Educ* 2015; 79 (8): 914-21.
4. Hankle J.L., Imbery T.A., Carrico C.K. Perceptual ability tests correlate to performance on a rudimentary dental anatomy laboratory exercise. *J Dent Educ* 2021; 85 (6): 821-27.
5. Chaulagain R., Lamichhane R.S., Pradhan A. Perception regarding tooth carving using wax block among dental students in Kathmandu. *J Nepal Dent Assoc* 2019; 19 (2): 18-22.
6. Siéssere S., Vitti M., Sousa L.G., Semprini M., Regalo SCH. Educational material of dental anatomy applied to study the morphology of permanent teeth. *Braz Dent J* 2024; 15: 238-47.
7. Gazit E., Eini R., Hirsh N., Troest T. The use of replacement wax carving technique in teaching dental morphology. *J Dent* 1980; 8 (3): 270-74.
8. Daniel J., Sinduja P., Lakshmi T.A. Comparison of tooth carving technique between various academic year students of dental college in Chennai. *NVEO* 2021; 8 (4).
9. Kellesarian S.V. Flipping the dental anatomy classroom. *Dent J* 2018; 6 (3): 23.
10. Fonseca A., Guimarães V.B.S., Rodrigues-Junior S.A., et al. Effect of dental course cycle on anatomical knowledge and dental carving ability of dental students. *Anat Sci Educ* 2022; 15 (2): 352-59.
11. Mahrous A., Elgreatly A., Qian F., et al. A comparison of pre-clinical instructional technologies: Natural teeth, 3D models, 3D printing, and augmented reality. *J Dent Educ* 2021; 85 (11): 1795-1801.
12. Nance E.T., Lanning S.K., Gunsolley J.C. Dental anatomy carving computer-assisted instruction program: An assessment of student performance and perceptions. *J Dent Educ* 2009; 73 (8): 972-9.
13. Bilir H., Aygüzen C. The soap carving versus the digital sculpting: Evaluation of students' preferences and performance in dental anatomy course: Pilot study. *Eur J Dent Educ* 2022; 26 (1): 216-22.
14. Hamdy T.M., Abdelnabi A., Abdelraouf R.M. Reinforced dental plaster with low setting expansion and enhanced microhardness, *Bulletin of the National Research Centre* 2020; 44: 78
15. Lee Y.K. Criteria for clinical translucency evaluation of direct esthetic restorative materials. *Restor Dent Endod* 2016; 41 (3): 159-66.
16. Faheem S., Qasim R., Zaidi S.J.A., Maqsood S. Clinical relevance of wax carving and its integration in the undergraduate dental curriculum: students' perceptions and experiences. *Int J Dent Oral Sci* 2022; 9 (3): 5264-8.
17. Nayak M.T., Sahni P., Singhvi A., Singh A. The perceived relevance of tooth carving in dental education: Views of practicing dentists and faculty in West India. *Education for Health* 2014; 27 (3): 238-42.
18. Kara R., Velibeyoğlu M.B. The effect of tooth carving technique on dental technician student perception and performance in tooth morphology and manipulation course. *J Health Sci Med* 2022; 5 (2): 19-25.
19. Ennes J.P., Souza A.S., Cunha I.P, et al. Teaching tools in dental carving: models, virtual resources, and interactivity. *Rev ABENO* 2018; 18 (1): 45-55.
20. Maragha T., Chehroudi B. Assessment of the students' performance and support needs in a novel digital carving exercise. *J Dent Educ*. Published online February 6, 2024.
21. Hsu M.-S., Yeh C.-L., Cheng S.-J., Lin C.-P. Transforming Dental Morphology Education: The Impact of Three-Dimensional Digital Simulation on Practical Skill Development. *Int Dent J*. 2025; 75 (6): 103904.