

Under the Lens: A Report on Global Dental Morphology Modules

Bajo la Lupa: Un Reporte sobre los Módulos de Morfología Dental a Nivel Global

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SUMMARY: Dental morphology (DM) is the first introduction of dental graduates towards the identification of tooth; hence it is an important component of the dental curriculum. Traditionally, it is taught by manual carving of wax blocks, but the limitations of this method have been highlighted. There is a need to adopt innovative teaching methodologies to invigorate the concepts of dental anatomy (DA) and reduce the stress in teaching and learning with a proposal in standardization of training methodologies worldwide. Methods: A three-phased project was designed with an aim to collect global data related to teaching dental morphology within the dental curriculum. One dental professional actively involved in university teaching of DM subject was invited from 11 countries. The present study involved compilation of data from phase 1 questionnaire responses, followed by its discussion and analysis, and generation of preliminary report. Results: It is universally acknowledged that acquiring dental morphology knowledge by dentists is a prerequisite before they commence clinical practice. Our data points that no uniformity in DA course modules exists throughout the world and globally the subject requires curriculum redesigning. Conclusions: Consensus should be achieved amongst academicians in DM teaching and learning context. Innovative and standardized DM modules with component of computer-based and remote learning techniques should also be introduced.

KEY WORDS: Dental Morphology; Dental Anatomy; Dental Curriculum; Dental Education; Tooth Carving.

INTRODUCTION

The dentistry entails prevention and treatment of oral diseases, including diseases of the teeth, its supporting structures, and the soft tissues of the mouth (Ring *et al.*, 2018). A dental specialty is different from the other disciplines of health care, as it incorporates sound theoretical

knowledge along with practical training involving hand dexterity and motor skills, taught at different levels of undergraduate and post-graduate curriculum (Rucker, 2007). Of these, the subject of Dental anatomy (DA)/ Dental histology (DH) taught at the undergraduate pre-clinical level, is the

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first introduction of dental undergraduates to teeth and their anatomical characteristics. Teaching Dental morphology (DM) involves sound foundation of morphology principles and functions along with manual reproduction of tooth structure, both functionally and artistically (Chowdhry & Sircar, 2020). The teaching of morphological sciences in general tends to present difficulties in understanding both images and shapes, which mandates an approach through skills of a special nature to build knowledge (Fonseca & Fonseca, 2010). Mostly the training hours of preclinical dental anatomy are spent to appreciate the surface outlines of the oral structures, the gross and microscopic anatomy of each tooth, and the contact relationship between teeth in the primary and permanent dentition and jaws (Nayak *et al.*, 2014). During the training, students are taught cognitive and psychomotor skills related to the morphology and are introduced to the spatial and functional relationships of the human dentition (Obrez *et al.*, 2011). Traditionally, DM is taught in didactic teaching, with reinforcement of knowledge by curriculum textbooks and manuals. However, the psychomotor skills for recognition and reproduction of dental structures and morphology have progressed from the traditional methods of carving wax blocks to more advanced methodologies. The comparison of both the methods is presented in Table I.

The modified pen grasp is the most preferred precision grip used by dentists for the micromanipulation with hand instruments in dentistry (Makinson & Hume, 1982). DH wax carving teachers are probably the first instructors in dental curriculum to introduce students to this advantageous grip. Students can adapt at an early stage of training and have a better control and strength when using hand instruments in clinics. Moreover, teaching and learning DM are known to enhance proficiency in restorative dentistry, dental surgery, prosthodontics, and endodontics rehabilitation and hence improve patient care, along with assisting in the identification of abnormalities or pathologies (Lone *et al.*, 2018).

The traditional methods (highlighted in Table I), have various limitations. These limitations have generated opinion

of various authors (Sivapathasundharam, 2008; Baskar, 2009; Rao, 2010):

- Part of primitive outdated dental curriculum.
- Wasting of productive time.
- Not relevant to current times.
- Unclear rationale of root carving (Sivapathasundharam, 2008).

Further, Obrez *et al.* (2011) have concluded that there is no standardized, acceptable methodology of teaching and evaluating DM via wax carving for student training. The need to revitalize the discipline of dental anatomy and the necessity to adopt innovative teaching methodologies has been highlighted (Ranganathan, 2010; Chowdhry & Sircar, 2020). Magne (2015) proposed an approach with emphasis on visual arts and the 2D-3D-4D concept. In 2020, Mladenovic presented augmented reality techniques for teaching dental morphology and for simulated environments in different clinical dental procedures (Mladenovic, 2020). Also, the current COVID-19 pandemic situation has provoked the need to adapt medical and dental training to a non-contact mode. Hence, it is more likely that hybrid and innovative methodology teaching will be the “new normal” and there is an absolute need to develop methods to teach tooth carving on a digital platform in an asynchronous mode (Chowdhry & Sircar, 2020; Chowdhry *et al.*, 2020). The strengths of the new system may include familiarizing current young generation of students with E-learning modes. Remote learning may as well empower the students to control the speed of learning, allow multiple revisions and hence, be more effective. The limitations, on the other hand may be that the need for student self-discipline with time deadlines for each assignment. Hence, a 3-phased project was designed with an aim to collect global data related to teaching DM within the dental curriculum. The compiled data was used to evaluate future prospects and directions of teaching DA and DM training to undergraduates and to cope with more effective and contemporary clinical and digitally applicable techniques and methodologies. A final draft proposal is also outlined in sync with the distance learning requirements.

Table I. Comparison of traditional and advanced methodologies for learning dental morphology.

Traditional:	Advanced:
1. Studying gross anatomy of preserved tooth specimen.	1. Examining 3D prints
2. Learning from Plaster replicas (proportional large models)	2. Learning from virtual 3D models.
3. Studying cross-sections preserved tooth specimens	3. Haptic devices to touch-back and learn dental anatomy.
4. 2D line drawings	4. Virtual carvings and dissections of oral structures.
5. Carving teeth from wax blocks	5. 2D-3D-4D concept: drawing/wax-ups exercises and layering
	6. Augmented reality (AR)

MATERIAL AND METHOD

The global data compilation related to teaching dental morphology took place in 3 phases: Phase 1, was the consent and questionnaire phase. One dental professional involved in university teaching was selected from 11 countries: Australia, Chile, Croatia, India, Indonesia, Italy, Malaysia, Nepal, Pakistan, Romania, and Turkey. Each participating dentist gave consent and filled an online questionnaire (Table I) with subjective and objective components. The questionnaire was in semi-structured format on global dental morphology modules consisting of majorly closed ended questions (8 out of 11). Phase 2 was the compilation and interpretation phase. Based on the responses to the phase 1 questionnaire, data related to dental morphology module in each country was compiled, discussed, and analyzed, and a report was generated. Phase 3, was the approval and final draft phase. The compiled phase 2 report was sent back to each author for correction and approval.

RESULTS

Results of questionnaire were compiled and presented in Table II. Different specialties are involved in teaching DM across various countries. The different branches documented were oral pathology (3 out of 11), dental materials (3 out of 11), oral biology (2 out of 11), prosthodontics (2 out of 11), restorative dentistry (2 out of 11), dental anatomy and general anatomy in one country each, and taught in adult clinic or general dentists in single country each. There is an overlap of two or more specialties undertaking this teaching in more than one country.

Eight out of 11 countries teach this subject in the first undergraduate year (only one semester in Romania), while the other 3 teach this subject in the second year. Additionally, it is also taught in the fourth year in two countries. While all 11 countries agreed to give demonstration of wax carving to students, the group size of students for demonstration varied. Six out of 11 countries mentioned a group of less than 10 students, and 4 countries mentioned a group of less than 20, but none of the countries accepted a projector-based method demonstration to a larger group of greater than 20 students. Five out of 11 countries mentioned carving of all permanent teeth, 3 countries reduced them to few permanent teeth but only one country (Croatia) mentioned carving both sets of deciduous and permanent teeth.

Going into details of carving, only the crown section is carved in 4 out of 11 countries while the remainder carve

both crown and root. The importance of wax carving as an essential part of DM teaching is recognized in 9 out of 11 countries. "Wheeler's Dental Anatomy, Physiology and Occlusion" was the most recommended text book to undergraduates for Dental Morphology (4 out of 11 countries). Besides text books, illustration guides and drawings were also emphasized in 2 countries. However, in postgraduate training, wax carving was not a recommended practice and was mentioned in only 4 out of 11 countries. In terms of teaching aids, plaster replicas of teeth were most frequently used in 10 out of 11 countries, extracted teeth in 8 out of 11 countries, virtual 3D models in 4 countries and 3D prints used in 2 countries. As per additional aids, videos are used in 7 out of 11 countries, audio and computerized 3D models in 4 countries each, while use of mobile applications was seen in 2 countries (Malaysia and Romania).

DISCUSSION

The response rate of our questionnaire was 100 %. Results of the questionnaire bring forth the practices and ideologies behind DM teaching at the international level. It is known that microscopic and macroscopic knowledge of teeth is of paramount importance in dentistry, especially in restorative dentistry context (Sivapathasundharam & Prottyusha, 2021). It has been found that thorough knowledge of DA is required for identification and diagnosis of normal and pathological anatomy of teeth (Siéssere *et al.*, 2004; Patil *et al.*, 2015). All these facts highlight the importance of learning DA at the entry level dentistry study, prior to subsequent postings in clinical departments. This factor has been highlighted in the results of the current questionnaire where most countries recognize importance of teaching DA in first undergraduate year. Additionally, it is also taught in fourth year in two countries to highlight the importance of detailing anatomy of teeth prior to performing fillings and restorations in conservative dentistry or construction of crowns in prosthodontics with perfect anatomical precision. This allows the concerned educators to impart cognitive and psychomotor skills related to identification, replication, and restoration of tooth morphology in newly enrolled students apart from delivering the didactic content. Although there is currently discussion about the ethical and legal issues of the use of extracted human teeth in dental education (Holden & Dracopoulos, 2017; Qutieshat *et al.*, 2020), our report points out that natural teeth carved out of wax blocks is a most practiced method worldwide for teaching and learning tooth anatomy. The development of this skill requires practice and the process of wax carving itself ensures that the concepts of tooth morphology (especially size and shape) are deeply imbibed (Chowdhry & Sircar, 2020). Although majority of

Table II. Questionnaire global dental morphology modules.

S.No.	Question	Australia	Chile	Croatia	India	Indonesia	Italy	Malaysia	Nepal	Pakistan	Romania	Turkey
1	1. Tooth morphology is being taught in which year of dental undergraduate curriculum? (in your country)	Dental Anatomy	General Anatomy, Adult clinic	Oral Pathology, Restorative Dentistry	Oral Pathology	General Dentists, Dental material	Restorative Dentistry	Oral Biology	Oral Pathology	Oral Biology	Prostheses Technology and Dental Material	Prosthodontics [Dental Materials and Manipulation Training under the Speciality of Prosthodontics] 1st Year
2	2. Tooth morphology is being taught in which year of dental undergraduate curriculum? (in your country)	1st Year	1st Year	2nd Year 4s year	1st Year	1st Year	2nd Year 4s year	1st Year	2nd Year	1st Year	1st Year, 2nd Semester	1st Year
3	3. Is demonstration of teeth carving given to dental undergraduate students by faculty? (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	4. What is the usual student to teacher ratio while giving a demonstration of carving on wax block? a) No demo was given b) group of less than 10 c) group of less than 20 d) more than 20 on a projector e) more than 20 without a projector	b	a	c	c	b	b	b	b	c	b	c
5	5. Dental undergraduate students are told to wax carve: a) All deciduous teeth b) All permanent teeth c) Few deciduous teeth d) Few permanent teeth e) Both sets are carved f) No strict rules to carve Wax carving is not part of curriculum Undergraduates are required to wax carve following part of tooth: a. Only crown b. Entire tooth c. No one	c	f	e	b	d	b	d	b	b	d	b
6	6. Is wax carving of teeth an essential component for a assessment in subject of Dental Anatomy? (Yes/No)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	7. Which is the most recommended book to undergraduates for Dental Morphology?	Wheeler's Dental Anatomy, Physiology and Occlusion	Wheeler's Dental Anatomy	Ash MM, Nelson SJ Dental anatomy, physiology and occlusion. Philadelphia; Saunders; 2003.	Wheeler's Dental Anatomy, Physiology and Occlusion	Wheeler's Dental Anatomy, Physiology and Occlusion	Dental drawings, tables and libraries distributed by the professor	Dental Morphology: An Illustrated Guide by G.C. Van Biek	Wheeler's Dental Anatomy, Physiology and Occlusion	Concise Dental Anatomy and Morphology by Gerald E. Densley and James L. Fuller	Romina M. Bratu D. Urnu-Tuculescu S. Constantinica MV. Loretter M. Bodnar V (1997) Dental Maxillar Apparatus: clinical functional morphology data. Helikon Publishers, Timisoara, Romania	Yavuzilmuz H. Dis Morfolojisi Fizyolojisi ve Okuluzyon. [Tooth Morphology- Physiology and Occlusion] 5s Ed. 2007. Guit Universitesi Publication No 213. Ankara
8	8. Is wax carving of teeth on wax blocks part of Post-Graduate training programs? (Yes/No)	No	No	No	Yes	Yes	No	Yes	Yes	No	No	No
9	9. Following 3D models are used for teaching dental morphology (in your country)	a, b, d	a, b	a, b, d	a, b	a, b, d	a, e	c	a	a, b, e	a, b, d	a, b, c, d
10	10. What are special advanced aids being used for teaching Dental Morphology theory and wax carving practicals? a) Videos b) Audio clips c) Computerised 3D models d) Mobile applications/ Computerised software's e) Photographs/other	a, b	e, only photographs	a, c	a, b	a, b, c	e. Plastic models of teeth	d	a	e	a, b, c, d	a, c

countries have developed modules for practical training by means of wax block carving of permanent and deciduous teeth, but it is still controversial as previous literature suggests carving oversized blocks or drawing projects (2D) as a hindrance to translation of these manual/ literary skills in patient care (Obrez *et al.*, 2011). To overcome the cognitive and psychomotor developmental limitations with the conventional DA teaching, the University of Illinois (Chicago, USA) modified the DA course module (Holden & Dracopoulos, 2017) to include didactic and laboratory components. The module instructed students to refer to recommended resources of textbooks, CD ROMS (including cases and figures) as well as slideshow software (Holden & Dracopoulos, 2017). Similar teaching aids have been evaluated across 11 countries

in the questionnaire section. The only difference is that the standard textbooks for referral are different in all the countries, with Wheeler's DA book being the most popular book. Additionally, 2-D drawing and illustration manuals have also been recommended. Regarding the cognitive development, the Chicago module encouraged small group discussions mediated by the instructor (Holden & Dracopoulos, 2017), which has not been recommended yet in any of the countries in the current study. However, the current questionnaire does bring forth practical demonstrations in small groups of below 10 or 20 students in the results. Additionally, for psychomotor development, wax carving of teeth and missing tooth structure was recommended in the Chicago module (Holden & Dracopoulos, 2017), which has proven significant improvement in the psychomotor development of student compared to the conventional module. This component was as in accordance with the findings of the current study. The only conflict noticed was promoting wax carving exercises in undergraduate teaching but not in post graduate teaching across multiple countries. The Chicago module in 2007 depended on slideshow software and CD ROMs but the current practice across various countries have graduated to video, audio, and also mobile application aids. In addition, countries are also employing 3-D virtual models or 3-D prints which can be an advantage in remote learning aspects, keeping in mind the current pandemic times. These current innovations in DA modules are synchronized with the 2D-3D-4D concept brought by Magne (2015). It emphasizes the visual arts, starting with the drawing of the tooth structure (2D/3D), followed by partial wax-up exercises, only to progress to histo-anatomical detailing of enamel/dentin and optical depth in mock-ups or resin restorations. The advantages of these procedures include teaching detailed tooth morphology and direct translation in patient care. There are other recent studies which focus on other teaching aids including lecture PowerPoints®, recordings, self-assessment questions, quiz on Kahoot™, YouTube™ videos, 3D sketchFab™ models, i-books, web-based programs, e-Biolabs™, etc. but PowerPoint® is still the preferred mode of communication (Lone *et al.*, 2018). Additionally, the preferred mode of teaching in this study on UK institutions referred to use of extracted and plastic teeth for teaching DA, but the latter was not recommended for anatomical detailing (Makinson & Hume, 1982). Similar pattern has been shown in our current project where plastic and extracted teeth are preferred 3D mode of teaching DA among students. Although the importance of carving has been established in the process of psychomotor skill development of students but carving complete tooth or crown or root alone are varied schools of thought followed across the world. The results of the current study show complete tooth carving being the preferred practice, in

accordance with the studies which have questioned the carving of root morphology alone (Rao, 2010; Mladenovic, 2020). It has been pointed out that the very purpose of root carving is questionable (Sivapathasundharam, 2008; Sivapathasundharam & Protyusha, 2021). "A good lecture class, explanatory charts, three-dimensional models, dry specimens, and an interactive multimedia presentation alone would suffice to make the students understand root anatomy" (Sivapathasundharam & Protyusha, 2021). Contrastingly, our data reports that entire tooth carving (including the root) is being practised the worldwide over, which can be attributed to the fact that carving the entire tooth might help in understanding root outer dimensions which might be useful in extractions of teeth or in orthodontics while applying pressure for apposition or deposition of bone. Nevertheless, there is still a creative debate regarding practical usefulness of tooth carving exercises, where some are in favor with some suggestions on evolution in practices and some consider it totally obsolete (Rao, 2010; Patil *et al.*, 2015; Lone *et al.*, 2018; Mladenovic, 2020; Qutieshat *et al.*, 2020). However, the outcome of the current project points towards certain similarities and dissimilarities across countries while imparting education of DM and DA. Despite the debate on tooth carving, it is universally acknowledged that acquiring dental morphology knowledge by dentists is a prerequisite before they commence patient- practice. It certainly forms the basis of multiple clinical procedures, including restorative, inlays, onlays, crown procedures, involving wax-patterns (Obrez *et al.*, 2011; Nayak *et al.*, 2014). Also, it is required to evolve and constantly reform the teaching methods and outcomes and propose newer innovative teaching modules.

Need for innovative course module: Traditional dental anatomy learning methods include examining gross anatomy of extracted teeth, studying cross-section specimens; drawing grid based 2-Dimensional (2-D) diagrams, and carving teeth from wax. All these teaching methodologies have very little clinical application as well as less purpose in present day context (Ponniah, 2010; Obrez *et al.*, 2011). Academics at University of Illinois at Chicago College of Dentistry have suggested revision of dental anatomy module, with an objective of enhancement of the subject by adding clinically applicable psychomotor and cognitive skills (Obrez *et al.*, 2011). It has been suggested to incorporate computer-based learning in the tooth carving modules of undergraduate students for improved teaching and learning (Juneja & Juneja, 2016). Software-based teaching along with interactive class meetings have resulted in positive feedback from students (Bogacki *et al.*, 2004) and artificial intelligence-based solutions should be introduced in dental education (Schwendicke *et al.*, 2020).

CONCLUSIONS

Our compiled report clearly points that there is no uniformity in DA course modules globally. The entire curriculum of DM teaching needs redesigning. Concerned national and international academies, societies and councils should try and get innovative and computer-based techniques incorporated in teaching DA. Though differences in opinion exist world-wide in teaching DM methods, but wax block carving is here to stay. Merits and demerits of including root carving in DM teaching modules needs to be discussed on global platforms. Consensus should be achieved, and dental fraternity should move together in correct direction with common objective of making better clinicians and researchers.

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RESUMEN: La morfología dental (MD) es el primer contacto de los estudiantes de odontología con la identificación del diente; por lo tanto, es un componente importante del plan de estudios de la carrera. Tradicionalmente, se enseña mediante el tallado manual de bloques de cera, pero se han destacado las limitaciones de este método. Existe la necesidad de adoptar metodologías de enseñanza innovadoras para dinamizar los conceptos de anatomía dental (AD) y reducir el estrés en la enseñanza y el aprendizaje con una propuesta de estandarización de metodologías de formación, a nivel mundial. Métodos: Se diseñó un proyecto de tres fases con el objetivo de recopilar datos globales relacionados con la enseñanza de la morfología dental dentro del plan de estudios dental. Se invitó a un profesional de la odontología de cada uno de 11 países que participa activamente en la enseñanza universitaria de la MD. Esto incluyó la recopilación de datos de las respuestas a un cuestionario en la fase 1, seguida de su discusión y análisis, y

la generación de un informe preliminar. Resultados: Se reconoce universalmente que la adquisición de conocimientos de morfología dental por parte de los odontólogos es un requisito previo antes de comenzar la práctica clínica. Nuestros datos indican que no existe uniformidad en los módulos del curso de AD en todo el mundo, por lo que el tema requiere un rediseño del plan de estudios. Conclusiones: Debe lograrse consenso entre los académicos en el contexto de enseñanza y aprendizaje de MD. También se deben introducir módulos innovadores y estandarizados de MD con componentes de aprendizaje remoto y de base digital.

PALABRAS LLAVE: Morfología Dental; Anatomía Dental; Plan de estudios dental; Educación dental; Tallado de dientes.

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