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Dental Anatomy and Occlusion: Mandibular Incisors—Flipped Classroom Learning Module

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Abstract

Introduction: This dental anatomy module is the second in a series that develops skills in analyzing the morphology, function, anomalies, and development of human teeth. Learning the visual details associated with teeth has often proven difficult using the lecture format; thus, we have utilized computer-assisted flipped learning, which has been shown to be just as effective as lectures and frees up class time for active learning. **Methods:** In a flipped classroom approach, students learn basic knowledge with a self-paced, interactive tutorial prior to class. In class, students are assigned to small groups and start with a readiness assessment quiz, administered first individually and then to each team. This is followed by a review for the whole class. The teams then practice critical thinking through practical application scenarios; a laboratory exercise follows where students wax tooth #25 and tooth #26. **Results:** Students rated faculty members who used team-based learning higher than those who used lecture format for similar morphology lectures. For the first 3 years that this flipped classroom technique was used, students consistently scored it higher than the lecture format on a 5-point Likert scale. Multiple positive comments indicated their preference for this method. **Discussion:** Teaching students to see the subtle variations in tooth morphology takes time and attention. In a lecture, each key point is covered only once, and images appear fleetingly. A key advantage of the self-paced interactive tutorial coupled with flipped classroom activities is that each learner can take the time needed with each image in a tutorial.

Keywords

Flipped Classroom, Dental Morphology, Mandibular Incisors, Preclinic Dental Education, Dental Hygiene

Appendices

- A. Tutorial Mandibular Incisor .pptx
- B. Quiz Mandibular Incisors .docx
- C. Class Session Mandibular Incisors.pptx
- D. Immediate Feedback Form .pptx
- E. Handout Mandibular Incisors.pptx
- F. Rubric Maxillary Incisor .docx

All appendices are peer reviewed as integral parts of the Original Publication.

Educational Objectives

By the end of this module, the learner will be able to:

1. Describe the form and features of mandibular incisors in detail, using height of contour, outline form, cervical outline, imbrication lines, lingual fossa, and cingulum.
2. Explain mandibular incisors in function.
3. Describe the difference between the mandibular central and lateral incisors in all aspects, comparing them to maxillary incisors learned previously.
4. Identify natural teeth by sight.
5. List from memory the important developmental and eruption dates of mandibular central and lateral incisors.

Introduction

Central to the practice of dentistry is the ability to develop a deep understanding of the shapes of teeth, in this case, mandibular incisors and how they compare to and function against maxillary incisors, as well as being able to reproduce these shapes in wax to mimic restorative material. However, the knowledge base is primarily a highly detailed description of tooth morphology, which does not lend itself to lecture format since it tends to be somewhat difficult for a lecturer to keep students focused upon the many subtle details involved. This resource offers an alternative, flipped format module intended for first-year dental and dental hygiene students. It is one in a series of 28 dental education modules in a course entitled Dental Anatomy and Occlusion.

Numerous articles and systematic reviews have shown that various types of computer-assisted learning are generally at least as effective as lectures and may be more time efficient and that students tend to like the computer-assisted learning formats better.¹⁻⁶ A key advantage, which is generally not mentioned, is that delivery of the knowledge base prior to class time by computer-assisted learning supports a flipped classroom approach, in which the class time can then be used for active learning and refinement of critical thinking skills. As the accrediting body for dental education, the Commission on Dental Accreditation endorses an educational environment goal that encourages “strategies that foster integrated approaches to learning” as part of promoting deep learning and critical thinking in “the application of knowledge in clinical reasoning.”⁷

Team-based learning (TBL), originally developed by L.K. Michelson in the early 1990s for a case-based business class, has been shown to be an effective method of implementing small-group active learning in a large classroom with a single facilitator.⁸ It has been adopted in many areas of professional health education, including in medical, pharmacy, and nursing schools.⁹⁻¹⁴ Studies have also shown its effectiveness in dentistry,¹⁴⁻²⁰ with some evidence to suggest that TBL shows particular benefit in furthering the education of lower achieving students.¹³⁻²¹ While this module uses many of the techniques of TBL, modifications have been made based on facilitator observation as well as student feedback, so we described the module more generically as a flipped classroom resource.

The basic steps to implementing this flipped classroom module include the following:

1. Prior mastery of a knowledge base before the class period.
2. Small-group assignment: For the classroom session, the class is divided into small groups of four to six students, in this case, alphabetically, not self-selected, and each group is assigned an identifying number.
3. Completion of a readiness assurance test: Given at the start of classroom session, the quiz is taken individually. The answers are reviewed as a class to ensure that the main points are understood by all class members.
4. Use of immediate feedback application exercises: In the critical thinking portion of TBL, increasingly complex practical or clinical scenarios are presented using three formats. The first is intragroup discussion, where each small group determines the best responses to a question about a case. These group answers are simultaneously reported by raising whiteboards with the answer. Next is intergroup discussion, where the facilitator scans the group responses and spots trends, then facilitates an open-class discussion among groups to develop a consensus around the correct answer. The last is a final graded activity using clinical cases or other types of problems that require applying knowledge and critical thinking skills.

Currently, these techniques are not widely used in dental education. The term *team-based learning* is still unfamiliar to many dental educators, despite promotion by the American Dental Education Association Commission on Change and Innovation in Dental Education as far back as 2011. For example, at the 2016 annual American Dental Education Association meeting, only two sessions listed TBL in their titles. Moreover, in previous years, TBL was erroneously applied to generic team efforts such as community-based outreach programs, indicating a lack of familiarity with the term even at the programmatic level.

To date, little research has been done on dental educators’ attitudes regarding alternate techniques to lecture format, so it is difficult to judge why TBL is not more widely used. Unfamiliarity with flipped classroom techniques and a perception that converting lectures to flipped classroom tutorials is unduly time consuming or difficult may contribute to the slow adoption of the technique.²² The current module is offered as one example of this proven teaching technique in hopes of helping to overcome barriers to adoption of flipped classroom and TBL, as well as to increase acceptance of the methodology.

Traditionally, the core of learning dental morphology is having students create a tooth in wax. This allows students to explore these shapes in three dimensions with an inexpensive and reversible material. No other technique has been shown to be superior to waxing in developing hand skills or knowledge of dental morphology.²³ Having already been introduced to the technique of creating a wax model to create maxillary incisor teeth, students build upon this skill and compare the new mandibular shapes to their previous maxillary models.

In our experience, students introduced to dental morphology in the lecture format have difficulty transferring that knowledge to the associated laboratory exercise. Students sitting passively in a lecture do not seem to master the multiple detailed observations on the shape of a particular tooth and demonstrate little to no grasp of concepts such as height of contour or embrasures in practice. Faculty complain that they often have to repeat concepts that were just previously covered in the lecture to a majority of students one-on-one during the laboratory exercise. The flipped classroom format, on the other hand, facilitates active learning in the problem areas for students and allows the teacher to address any issues in the classroom.

Methods

This module begins with the prework tutorial (Appendix A), which is a self-paced, interactive PowerPoint that presents and reinforces the didactic knowledge base. For the class session, a sample readiness assessment test (Appendix B) is provided along with a class session PowerPoint (Appendix C), which includes the team application activities and the immediate feedback exercise form (Appendix D). After class, a concise version of the class session without the quiz and graded activity is distributed as a handout (Appendix E). The rubric published in the first module of this series²⁴ for the maxillary central incisor (Appendix F) can be employed in the process of comparing mandibular incisors to the previously fabricated maxillary incisor. A facilitation schema is provided below:

- 0:00-0:10—individual readiness assessment test.
- 0:10-0:20—review of quiz.
- 0:20-0:40—immediate feedback activities.
- 0:40-0:55—graded group activity.
- 0:55-1:10—break.
- 1:10-4:00—laboratory activity.

For the immediate feedback exercise, a small-crafts organizer (like those used for beads) is needed, with enough individual compartments for each group to be assigned one. Extracted human maxillary and mandibular incisor teeth are cleaned and sterilized according to Centers for Disease Control guidelines.²⁵ Each is identified by a knowledgeable faculty member using the Universal Numbering System. Two different teeth are placed in each individual compartment, and a key, recording the correct answers, is maintained by the assigned faculty member.

Team Formation

Teams consist of five members, selected by the instructor (alphabetically) and maintained throughout the whole semester. No substitutions are allowed.

Advance Preparation Resources

At least a week in advance of the class session, students are sent a copy of the interactive tutorial (Appendix A) with instructions to master the material. They are then informed that there will be a quiz covering the material at the start of class. Mastering the tutorial takes approximately 1 hour, as reported by students. Students are also advised to review the corresponding sections of assigned textbooks for

context,^{26,27} which takes less than 30 minutes. Students are encouraged to direct any questions they may have to the faculty via email prior to the classroom sessions.

Readiness Assurance Process

In the class session PowerPoint (Appendix C), a copy of the individual readiness assessment test is included as the last six slides, which can be printed as a handout of six slides per sheet, or a new quiz can be written from the tutorial material. The goal of this quiz is not to dwell upon minor details but to confirm that students have mastered the main points of the material. The suggested grading technique is to count off 10 points for each incorrect answer; only give a zero for an unexcused absence.

Quiz Review

The quiz is reviewed by the class using the class session PowerPoint (Appendix C). Questions are interspersed with the corresponding slides from the tutorial to reinforce concepts visually while minimizing arguments. Students are encouraged to ask clarifying questions if they do not understand the correct answer. One benefit of this method is that the instructor gets immediate insight into areas of confusion. Also, questions that are confusingly written or found to have reasonable alternative answers can be identified before the tests are graded. Students are allowed to challenge a test question in writing within 48 hours of the class period. Each group must challenge separately.

Immediate Feedback Activities

The remaining class time is devoted to reinforcing, exploring, and using the knowledge base for structured small-group problem solving through case-based scenarios. Each group is given a small lap-sized whiteboard, a marker, and paper towels for erasure, along with a printed copy of the immediate feedback form (Appendix D.)

Intrateam Discussion

The questions and images in the class session (Appendix C) are shown and briefly repeated by the facilitator. Students then discuss their answers, referring to the tutorial, textbook, or any other resources as they wish. Students are directed to write their answers on the lapboards. Then, when directed, they simultaneously reveal their answers, which can be via multiple choice or short answer. The pacing of this process is important, and the instructor has to decide when a useful discussion is completed and then call for the answer cards or boards to be shown simultaneously. Generally, 2 or 3 minutes should be enough for each question.

Interteam Discussion

The facilitator scans the answers on the boards and evaluates the discrepancies among answers. Using a microphone, members of representative groups are asked for their rationale for the answer that their respective groups selected. The facilitator is neutral, allowing the students to discuss their thinking to arrive at the correct answer. Wrong answers are supported, even welcomed, because they offer openings for the facilitator to highlight areas of misunderstanding. Again, no more than 2 to 3 minutes is required to address each question. The goal is to make this section a fast-paced, high-energy, interaction-rich environment that involves all students.

Graded Group Activity (Tooth Identification and Comparison Exercise)

Each group is issued its numbered container with instructions to examine the teeth contained therein, using appropriate Occupational Safety and Health Administration–designated personal protective equipment that includes safety glasses, gloves, and masks.²⁸ Each group determines the correct tooth number. If additional faculty members are available, they can listen in on group discussions and guide the decision process as each group identifies its teeth. Each group also completes the immediate feedback form (Appendix D), which compares maxillary and mandibular incisor morphology characteristics. After all

groups have made their decisions, the answer key slide is displayed.

Laboratory Activity

Students create a wax replica of the mandibular central incisor. The waxing demonstration video from the maxillary incisor module²⁴ can be used to reinforce the sequence of waxing and point out differences in morphology between maxillary and mandibular incisors.

Postclass

A summary file of the key information from the class (Appendix E) is sent to all students.

Optional Second Lab Period

If the faculty wish to have the students wax a lateral incisor, they can implement a second lab period. During this 3-hour period, the students create a wax model of a lateral incisor crown with the same sequence and techniques used to replicate the central incisor.

Results

This flipped classroom module has been used instead of a lecture for the past 6 years to teach the morphology and occlusion of the mandibular incisors to all learners in the first year of dental school, a class of 75-95 students at our institution. Learner satisfaction with TBL has consistently been higher than with the traditional lecture modules, and numerous comments specifically mention the TBL tutorials and overall format as especially helpful or as a preferred teaching approach.

Since 2014, TBL has been our format of choice in teaching tooth morphology. Our teaching transitioned from a traditional lecture format to this new TBL approach during the years 2011-2013. Analysis of the routine student feedback provided at the end of the courses allowed a comparison of student perceptions of the effectiveness of a lecture format versus TBL (Table). Nearly half of voluntary student comments concerned the TBL format, and all but one were positive. The following is a sampling of student feedback:

Table. Student Feedback Scores^a

Year	Average Faculty Score	
	Lecture Approach	Flipped Classroom Approach
2011	3.99	4.64
2012	4.01	4.16
2013	3.99	4.43

^aScale of 1 to 5, with 5 being most positive.

- “The PowerPoints were highly interactive and taught me the most regarding concepts and how to think critically. I wish the other professors would implement that style of teaching.”
- “Tutorials were fantastic . . . my only regret is that we need MORE of them. They really do help you retain the information well.”
- “Really liked the tutorials. I wish every session had been like that because it forces me to learn the material before class, so I get a better understanding of it.”
- “I liked the tutorials, and I believe that it is a better way to learn than the long in-class PowerPoint lectures.”
- “[Facilitator] would present board-style questions that we would work together as a group in order to reinforce those concepts and during every exam, her topics were the ones that I would always get right.”

When the traditional lecture format was used, faculty concerns about the class consistently centered on the students' lack of basic knowledge in the follow-on lab, despite the students having just heard the lecture. It was common to have a number of students who did not understand, for example, how the height of contour related to the proximal contact point even after a month in the course. Since the adoption of the TBL approach to teach these concepts, these concerns have faded away. Having students use the interactive tutorial and take a quiz before the class session starts sets an expectation of

preparation, and our experience is that the students then master the images and concepts at a higher level. With the class session now devoted to reinforcement of terminology and concepts that historically have been problematic, readiness for the skill laboratory is higher. Overall, faculty have observed that students start the lab session with a deeper understanding of the knowledge base and that learning in lab is more connected to the didactic learning.

The tooth identification activity, which teaches the skills of tooth identification in a structured group setting, has also proved very helpful. After being prepared in an informal, interactive way, students have reported less stress around objective structured clinical exam assessments that require them to identify extracted human teeth.

Discussion

Initially, resistance by several faculty members to using TBL was significant. Over time, their concerns that students would not do work before class and that the TBL methodology would not cover the material to the same extent as a lecture proved baseless. After the TBL approach generated both a significant positive reaction from students and an improvement in student performance in the laboratory, resistant faculty members adopted the flipped classroom method themselves. Now, all morphology sessions are done with this technique.

Teaching students to see the subtle variations in tooth morphology takes time and attention. In a lecture, each key point is covered only once, images appear fleetingly, and the sheer volume of what appears to a novice to be a host of minute details that must all be simultaneously and comprehensively mastered overwhelms students' short-term memory capacity. A key advantage of the self-paced interactive tutorial used in TBL over the traditional lecture format is that each learner can take the time needed with each image in the tutorial, returning as required for verification and comparison as the individual learner moves at his or her own pace through the module. Interactive quizzes embedded in the presentation, which help learners judge when they have mastered key concepts and are ready to move on, are a favorite feature with students.

TBL, as described by Michaelson,²² includes having students rate each other, and he feels it is critical to for students to be held accountable for their participation. However, we found (as has at least one other study²⁹) that professional students dislike this intensely and think it undermines the class cohesion that is perhaps more important in professional schools than in undergraduate education. In fact, multiple frank discussions with students have led to our conclusion that they are in agreement their high-performing, conscientious classmates have no need for an additional mechanism of accountability.

Creating ideal teeth in wax is an effective technique for promoting development of fine motor skills and refining a student's internal vision of morphology. The rubric published in the first module of this series²⁴ for the maxillary central incisor (Appendix F) can be employed in the process of comparing mandibular incisors to the previously fabricated maxillary incisor. Faculty are able to provide timely and accurate feedback to students during the process to refine their performance. While there are often calls to remove waxing from the curriculum, ostensibly because dentists currently rarely do their own wax-ups for diagnosis or fabrication of indirect restorations, waxing is still applicable to the teaching environment and to the development of basic hand skills.³⁰

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Ethical Approval

Reported as not applicable.

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