Discussion

One of the most important skills for any dentist is the ability to prepare and restore damaged tooth structure. The skills necessary to master this ability rely on the development of knowledge of the concepts of operative procedures and the dexterity to perform them. Faculty can offer instruction regarding the concepts of cavity preparation and demonstrate these techniques in large group sessions. However, the performance component requires that students repeatedly practice the preparations themselves. In the past decades, dental educators have come to realize that the clinical environment may not be the best environment for teaching. Reasons for this paradigm shift include technical skills that are increasingly more complex due to advances in knowledge, materials and technology. In parallel with the technological advances, financial restraints have increased the pressure for high patient turnover at dental school clinics, leaving less teaching time available to instructors and students.

For decades, dentistry has been investigating the extended use of simulation for its training, especially in the area of the preclinical curriculum. Factors that appear to be driving this interest are a desire to provide a smoother transition for students into the clinic, to support and reinforce ergonomics and to broaden the students’ preclinical experience by including additional models mimicking real patient conditions.

In 2002 the University of Tennessee embarked on a mission to create a state of the art dental simulation laboratory. The traditional black bench model was removed and replaced by two modern simulation systems. The first was a Kavo® (Kavo Dental Corp.) system providing the students a workstation, a fully adjustable manikin, electric handpieces and suction (Figure 1). The other simulator, called the DentSim®, provided the same features as the Kavo but additionally incorporates a computer, which evaluates real-time tooth preparation (Figure 2). Both systems provide true clinical simulation for students.

The University of Tennessee recognized that students of the computer generation are accustomed to being taught by computer-assisted learning (CAL) and/or simulation (CAS) and felt the DentSim® would provide such a virtual reality learning tool for dentistry. The advantages of computer-assisted learning are seen in self-paced and self-
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Directed learning and increase motivation. It is useful for objective, theoretical and practical tests and for training students to handle complex cases. CAL can lead to more structured learning and can support training in evidence-based decision-making.\(^2,3\)

The DentSim\(^\circ\) was developed, manufactured and distributed by Denx, an Israeli company. The system is unique in that it uses proprietary tracking and evaluation software to virtually follow the student’s progress while preparing a plastic tooth. The University of Tennessee faculty set the parameters for each preparation based on the cavity and crown designs taught in the didactic courses, which establishes the parameters for each preparation. Furthermore, the burs recommended for the same cavity or crown preparations were scanned and made available for the students within the evaluation software. The evaluation component of the software allows students to work seamlessly without waiting for a faculty member to critique their performance since this system provides instant feedback for all procedures (Figure 3).

This allows the student the ability to prepare more teeth in the same amount of time. A study by Jasinevicius et al., demonstrated that students trained using the DentSim\(^\circ\) required less faculty intervention and were able to prepare more teeth compared to students on other simulation systems. Students taught by other simulation techniques required five times more instruction from faculty.\(^4\) In addition, the design of the DentSim\(^\circ\) requires a student to sit and work in an ergonomic position conducive to the practice of dentistry (Figure 4). Audible signals as well as on-screen displays inform the student if their handpiece or sitting position is less than ideal. Additional audible signals inform the student of his or her progress during the preparation. By providing these tools the student improves his or her cognitive and motor skills at a faster rate.\(^5,8\)

The University of Tennessee purchased 40 Dentism units in 2002 thus making its simulation classroom the largest of its kind in the world (Figure 5). For the first few years the university tested the use of the simulation classroom and its possible integration into the curriculum. In 2004 the curriculum committee voted to add a DentSim\(^\circ\) based course to the operative
program. The course, titled “Tooth Preparation,” would be a prerequisite for the operative lab course. First-year dental students would commence the Tooth Preparation course on the first day of dental school and it would last for 12 weeks during which time the students would have two timed practicals; the first consisting of two preparations in the mandibular arch and the second consisting of two in the maxillary arch.

Since 2004 the Tooth Preparation course has been an integral part of the first-year dental student’s introduction to principles of cavity design. Course evaluations have been high, as students have found significant benefits with the use of the DentSim®. Since 2006, students have evaluated the Tooth Preparation course as it compares to other courses they are taking. The students were asked to rank the course from one to five, with one being far below average and five being far above average compared to other courses. The average ranking was 4.45 (Figure 6). According to the literature, students surveyed felt their experience with the DentSim® better prepared them for other pre-clinical courses (operative, fixed) and eventual patient treatment.9

Continuing the trend of Tennessee providing the latest simulation technology for their students, the College of Dentistry, with the financial support from Delta Dental of Tennessee, purchased 20 new DentSim® units in April of 2010. The new units were fabricated by Saratoga, an Italian company, for Image Navigation. These new units are advanced ergonomically, designed by the renowned Italian carmaker Pinin Farina, and the University of Tennessee will be the leader in utilization of these units (Figure 7). The College of Dentistry also added four Image Guided Implantology (IGI) units in the transaction.

The IGI component uses the same proprietary tracking technology to allow surgeons, prosthodontists, periodontists and general practitioners to precisely place dental implants in real time. The exact drill position is tracked in real time and displayed for the user to follow during placement. Due to its tracking technology, Image Navigation advocates that the IGI system removes the need for surgical guides (Figure 8, 9).

Some studies have shown stereolithographic surgical guides have
significant limitations and are far from being an ideal solution for supporting implant placement. The mean linear accuracy of implants placed with stereolithographic guides is reported to range between 1.1 mm to 1.45 mm at the implant neck and between 1.41 mm to 2.99 mm at the implant apical tip (Figure 10). The mean angular deviation is reported to range between 2 degrees to 7.25 degrees. A recent study by Elian, et al., investigated the accuracy level in placing implants using the IGI. The mean linear accuracy was less than 1 mm at both the implant neck and apical tip (Figure 9) and the reported mean angular deviation was less than 4 degrees (Figure 11). The research to date indicates the IGI improves the clinician’s cognitive and motor skills for placing implants by providing the ability to conduct multiple surgical rehearsals. The four units associated with the DentSim® lab at the University of Tennessee allow faculty, undergraduate students and graduate students in Prosthodontics, Periodontics and Oral Surgery to input patient CT scans, plan surgeries and practice placing implants in CAD/CAM fabricated plastic jaws. The IGI is just another example of Tennessee’s commitment to providing students, residents and faculty with leading-edge technology for pre-clinical training and research.

**Conclusion**

Over the past few decades, computerized simulation in dentistry, medicine and other healthcare disciplines has played a major role in producing exceptional clinicians. With the introduction of dental simulators and state of the art DentSim® units into dental education, the training of dental students can be enhanced. With the addition of IGI technology, residents can now take part in this exciting advancement in the clinical training in implant placement. The University of Tennessee’s College of Dentistry continues to keep its training programs at the top by providing state of the art simulation for their students. All dental schools want their students to be the best dentists they can be because they are well-educated and feel more confident in the techniques they have learned. The DentSim® and IGI are tools to make this happen.

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References

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Questions for Continuing Education Article - CE Exam #32

1. Dental education has been impacted by advances in:
   a. Knowledge
   b. Materials
   c. Technology
   d. All the above

2. For decades, dentistry has been investigating [what] modality for training, especially the preclinical curriculum:
   a. Simulation
   b. Plaster models
   c. Videotapes
   d. All the above

3. Two modern simulation systems are made by:
   a. Kavo® and DentSim®
   b. Midwest and Lares
   c. Coltene and Whaledent
   d. Hanau and Whipmix

4. The DentSim® teaches both operative technique and:
   a. Proper attitude
   b. Proper ergonomics
   c. Orthodontic technique
   d. All the above

5. It has been reported that the Image Guided Implantology (IGI) units removes the need for:
   a. Sterile irrigant
   b. Surgical guides
   c. Pre-operative antibiotics
   d. General anesthesia

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