Control the anatomy; control procedural training

New teaching paradigms from 3-D printed procedural training replicas

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“We buy “New Tech” when we perceive that some part of our personal or professional lives could be managed more easily with this new tool. We bought billions of cordless and then wireless phones because we wanted to talk to anybody, any time, regardless of where we happened to be when the spirit moved us. And it was good. Beyond good was when Steve Jobs shoved computing power, endless content and the whole wide-world Internet through our mobile phones. Who knew?

That’s how I have experienced every one of my New Tech adventures. First I use it to imitate what we did before — i.e., replacing slide carousels with computers — only later to find creative possibilities never imagined. In my example, it was discovering the power that clinical video footage can bring to lectures.

In that transition, my first concern was how to fill a 10-by-30-foot screen with a single video projector, without the three side-by-side stacks of slide projectors we used before. After worrying that one to death, I realized that the greatest storytellers on earth — Hollywood, Bollywood, etc. — pitched their $100 million stories on a single screen — so why did I need three? After that small epiphany, I concentrated my efforts on how to do what they do, and now I can do much of what these masters of the entertainment universe do, in ultra-high-def, with just a laptop computer.

So has been my experience with 3-D printed tooth replicas. I went into stereolithography looking for a simpler method of teaching endodontic procedures, a way around the grossness — they are discarded body parts, after all — as well as the unpredictable nature of teaching RCT in the random anatomic forms found inside the extracted teeth that course attendees gather. What I encountered was much more profound than just having a training model that didn’t smell.

After about six months of experimentation, numerous experiments in polymer chemistry and a seemingly endless series of plugged-up print heads, we learned how to make clear TrueTooth® replicas that were radio-opaque with a pulp-colored medium inside each canal space that can be digested with sodium hypochlorite. TrueTooth procedural training replicas were born (Fig. 1).
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SEM of a dentin tubule cleaned with GentleWave™

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Here are the things I have learned about their use in the past year of teaching hands-on courses with them:

1) We can now, for the first time, teach RCT to dental students and dentists in an iterative manner, the same way astronauts are trained, by repetition.

Previously, in extracted teeth, a student faced with an anatomic endo challenge only got a single chance to get it right. No repeat attempt was possible, because no other tooth would ever be found with the same challenge, so procedural endodontic training had always been a random walk through the endo anatomy of patients' teeth. In the endodontic training era that just expired, it took about 250 to 500 RCT cases (me too) before the frequency of getting surprised by a new anatomic challenge began to wane. Now, students can launch themselves at the same anatomic challenge as many times as it takes for them to have it nailed. Attack the same 90-degree apical impediment in a DB root canal of an upper molar 15 to 20 times — with the same, exact challenge every time — and you will be the king of 90-degree apical canal curvatures thereafter. Now, even orthodontists can learn to do a mean RCT. This is a serious game changer for endodontic educators.

2) TrueTooth replicas are very effective when used in clear and then opaque form to teach mental imaging skills.

I begin each of my hands-on courses with a mental imaging exercise in a clear TrueTooth replica of a maxillary central incisor that has an apical canal bifurcation. I teach course attendees how to accurately bend K-files to enter and traverse that accessory canal, and I have seen this particular use of these replicas shorten students' timeline to competence as they watch all the idiosyncrasies of file function while working in an anatomically accurate canal space.

Students are able to see the bent file tip snapping past the accessory canal orifice at the same time they distinctly feel the attendant "click" of the file tip dropping into the secondary canal, and after a couple of tries they become proficient in negotiating into accessory canals with visual and tactile feedback. The next challenge is to remove the visual feedback loop by changing to an opaque TrueTooth replica, and invite the student to enter the same secondary canal anatomy by just feel instead of vision and feel. After conquering that challenge, they know how to correctly bend files and blindly sneak them into secondary anatomy using mental imaging to interpret the tactile feedback coming through the handle of the file.

After this exercise, it is a relatively short path to accomplishment of the same in a patient's root canal system. Mental imaging is the most important skill a dentist can bring to bear during RCT. For the first time we have a reproducible method of transferring this critical skillset. A game changer for sure.

3) While softer than extracted teeth, the heat-resistant polymer used to print TrueTooth replicas cuts crisply with high-speed handpieces — without gumming up burs.

At Dental Education Laboratories, we set the HS handpieces at one-third the typical RPM — giving the participant more authentic tactile resistance.

‘This new technology can easily replace extracted teeth and unauthentic models in endodontic training.’
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during access procedures. Also, while the TrueTooth replicas are more easily ledged than extracted teeth, I have found they are the equivalent of swinging two baseball bats on deck before going up to the plate against a pitcher.

If you can navigate these anatomically authentic replica canals without ledging any of the natural irregularities contained within, you are ready for prime time in real teeth, as you will have developed the requisite light touch all successful endodontists have. This is a more subtle advantage than those mentioned above, but no less helpful to educators, nonetheless.

When students use training models with canals that resemble a soda straw, students gain no experience in ledge avoidance — a vital skill they desperately need as they move from pre-clinical lab to clinic and start invading their patient’s teeth. These replicas deliver anatomically accurate training in a way never previously possible.

4) Now, educators can develop a procedural training curriculum around a series of classic anatomic tooth forms that walk undergraduate dental students through the most common endodontic challenges they will encounter in practice, as well as more difficult cases that can lead graduate students through a range of anatomic challenges they could not meet in five years of practice.

Now, course objectives met by each student are easily documented, a necessity for accreditation review.

5) Replicas can be designed and printed for surgical training, complete with soft tissue that can be incised, reflected and sutured; hard and soft bone tissues, as well as roots and their canals — all printed together with no assembly required — are encountered exactly as they are in a surgical procedure (see “A New paradigm in surgical training,” roots, Issue 1, 2014).

6) Replicas can be created with multiple versions at the same level of difficulty to provide a diversity of experience for students, and still other versions for testing replicas that are only available to educators and examining boards. For procedural testing to be fair to students, educators and examiners, they are all served by authentic, reproducible 3-D printed replicas.

With our modeling engineers and our new multi-ink printer, our goal is to build replicas of quadrants and full arches with a different TrueTooth replicas in every tooth position.

I’ve made the case that this new technology can easily replace extracted teeth and unauthentic models in endodontic training. Dental education just got better, but the home run of this new tool will inevitably bring educational applications never before imagined. Dental education will never be the same.

The Dental Education Laboratories website, DELendo.com, has a complete catalog of the 30-plus different TrueTooth replicas currently available; however if you don’t see a TrueTooth replica that rings your chimes — whatever the need — let us know.

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**about the author**

L. Stephen Buchanan, DDS, FICD, FACP, is a diplomate of the American Board of Endodontics and an assistant clinical professor at the postgraduate endodontic programs at USC and UCLA. He maintains a private practice limited to endodontics and implant surgery in Santa Barbara, Calif., and is the founder of Dental Education Laboratories, a hands-on training center serving general dentists and endodontists who want to upgrade their skills in new endodontic and implant technology. Dr. Buchanan can be reached through his business, Dental Education Laboratories, www.DELendo.com, info@endobuchanan.com.