Flatten the Learning Curve

3D printing changes the way medical students learn.

Carefully cutting open the cadaver's nose, the experienced surgeon points to the major vessels that had been invaded and lectures on the operation procedures while a group of medical students watch intently. They all wish they could get enough practice on the body before they enter the real world and operate on living patients. But cadavers are expensive, and pathologies cannot be ordered.

But things don't get much better when they start to practice on their own. Every patient has a unique pathology, and for surgical planning, surgeons only have the MRI/CAT data on the screen. In the words of Mark Roe, founder and CEO of Fusetec, "Football players train on weekdays and play on the weekend. Surgeons play and play and play."

"3D printing has really changed the way in which we train our surgeons."

Prof. Peter John-Wormald
Chair of the Department of Otolaryngology Head and Neck Surgery at Adelaide and Flinders Universities

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Case Study

Reproduce the Irreproducible

Nestled in Adelaide, a coastal city in Southern Australia, Fusetec is the first commercial anatomical soft tissue reproduction company in the country. Years ago, Mark Roe became fascinated by 3D printing technologies and wanted to find a problem to the solution. Realizing that a number of American hospitals and medical schools were already making use of Stratasys® technology, he knocked on the door of Stratasys in Minnesota and walked straight in.

"3D printed models completely change how medical students learn," said Roe, "and this is why we have developed a variety of products to help them flatten the learning curve." Surgical training is all about apprenticeship, and medical students have been traditionally trained on cadavers. However, there are several important issues with this method.

Cadavers are very expensive to acquire, transport, store, maintain and dispose later. They are also rare and difficult to obtain in developing countries. This means that students cannot get enough hands-on training; most of the time, they are passive observers. Practice makes perfect, but what if you don't get to practice? Furthermore, pathologies cannot be ordered — you get what you get. As a result, students have to wait a long time before they have a chance to practice on a specialized pathologies. From a teacher's perspective, this is highly troublesome, because the learning curve depends too much on the limited availability of cadavers, with pathology that cannot be controlled. In general, this type of unstructured, if not opportunistic, education cannot provide the rigorous training that surgical students (and their future patients) deserve.

With the Stratasys J750™ Digital Anatomy™ 3D printer, Fusetec is manufacturing a wide variety of medical models that solve all these problems. The J750 Digital Anatomy printer has a 0.014 mm accuracy and its materials, including the newly released TissueMatrix™, BoneMatrix™ and GelMatrix™, offer a gamut of Shore hardness, from 0 to 100. Consequently, these models can replicate the feel, responsiveness and biomechanics of actual human anatomy — pixel by pixel.

"It's not easy to print human anatomy, but if one man can do it, so can another," smiled Roe. First, the MRI or CT scans of the living patients are acquired. Then, they are segmented layer by layer with software. The engineers transfer the data to a CAT program to fix potential issues and then use GrabCad Print™ to select the appropriate texture, material and color. "Hit the print button, and the magic happens!"

Dr. Sammuel Sobey practicing on the 3D printed model.

A Real Game Changer

Prof. Peter John-Wormald, Chair of the Department of Otolaryngology Head and Neck Surgery at Adelaide and Flinders Universities, is busy operating on a 3D printed sinus model with juvenile nasopharyngeal angiofibroma (JNA), a rare benign tumor arising predominantly in the nasopharynx of adolescent males. JNA is extremely difficult to remove, as it invades the vital structures like nasal cavities in sinus. The multi-layer material used to print this model faithfully replicated the pathology in terms of color and texture. This allowed Prof. PJ (the name he goes by) to explain each step to the students and enabled them to try the procedure themselves later on.

“3D printing has really changed the way in which we train our surgeons,” commented Prof. PJ. The pathology on cadavers could not be predicted, hence the limited and uncontrolled experience. Yet with 3D printing appearing on the scene, surgeons can now order pathologies in large quantities. Not only can students get more practice, they could also choose different levels of complexity and difficulty — which means that they can tackle challenging conditions step by step. Furthermore, because all students get exactly the same models, it is much easier for the teacher to monitor their progress.

Dr. Sammuel Sobey, who is learning with Prof. PJ, completely agrees. “With 3D printed models, I can operate on the same conditions again and again, until I perfect my skills and become confident in my ability. I also get the chance to try rare cases that might otherwise only present at certain hospitals once or twice per year; in this way, I won’t be thrown a curve ball when I go from school to the operation room.” In addition, Dr. Sobey stated that he could operate on specific pathologies in these models, while these pathologies may not be present in cadavers.

The 3D printed models are also very helpful for surgical planning, according to Prof. PJ. Every year, 313 million surgical procedures are being performed, and as many as 4.2 million patients die within 30 days after the surgeries. It has been said that going through a surgery could be as dangerous as bungee jumping.

While the surgeons used to rely on CT scans for surgical planning, now these scans are transformed into patient-specific models that they can actually hold in their hands. The surgical plans, which used to exist only in the surgeons’ heads, can now be verified during the mock operation — and the risks are minimized. The detailed texture of each layer of the head — including the skin, bone, spinal fluid and brain tissue — has been developed to a point where it will bleed once under the knife.

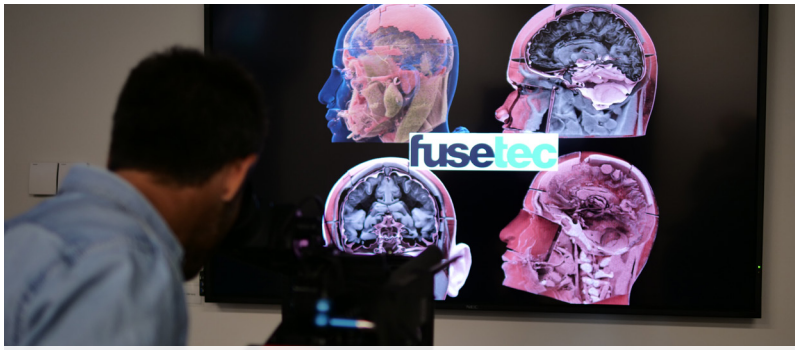
What the Future Holds

Prof. PJ has already run a course in Montreal and Adelaide, in which 40 surgeons participated. At their respective stations, those surgeons operated on exactly the same models based on real-life conditions under supervision. After they completed the course, they could watch the actual real-life video and find out what they had done wrong and learn how they could improve. This course has received marvelous feedback.

"The future for 3D printing in surgical training is infinite: where we can go, what we can do," commented Prof. PJ, who hopes to run similar courses in places where students and surgeons cannot practice on cadavers. More materials are still needed though. For instance, he envisions to have blood flowing in the vessels in future 3D printed models.

At this moment, Fusetec is providing brain models and frontal sinus models, but Roe is determined to expand the tech's capabilities into other anatomical areas, including the ear, thorax, eye and heart. Fusetec is also developing models for nurses who rely on live patients to practice skills, such as wrist cannula insertion. Each model costs only a fraction of the price of a cadaver. Roe concluded, "I am impressed by Stratasys' commitment to R&D. I surely can't do this without Stratasys technologies."

Hyperrealistic models printed by Fusetec.



Recording the operation on 3D printed models for students and surgeons.

Fusetec, the first commercial anatomical soft tissue reproduction company in Australia.

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