

Alexander Lin, M.D., is making new strides in pediatric reconstructive surgery.

ELENA ZHUKOVA FOR UCSF

Revolutionary Reconstructions

Alexander Lin, M.D., uses advanced 3D-printing technology to transform pediatric surgery at UCSF Benioff Children's Hospitals.

BY ESTHER CHAPMAN

During his long career as a plastic and reconstructive surgeon specializing in craniofacial and maxillofacial surgery, Alexander Lin, M.D., has seen the stuff of parents' nightmares: children shot in the face by a stray bullet, savagely bitten by a dog, or hit by a car. He has performed surgeries to fix birth defects such as cleft palates or misaligned jaws, as well as reconstructive surgeries on children marred by cancer.

One might think the work would wear on Lin, who is a father himself, but instead he's filled with wonder at how the body can be reconstructed and repaired through surgery techniques and technology, and the impact such procedures can have on real lives. Plastic surgery isn't just about aesthetics, he explains–it's about restoring a person's humanity.

"If you have a totally devastated face, you can't tell me that's simply cosmetic," he says. "Humans need to see each other's faces and facial motions to interact with each other. And speech–speech is not invisible; it's a vital human function for interaction. The ability to communicate is what makes us human and form bonds. Our field also includes hand surgery … One of our defining human features is our hands to create, touch each other, and communicate."

Lin's overarching mission is to help restore patients' abilities to see, smile, eat, speak, and use their hands. Now, as director of surgical innovations for UCSF Plastic Surgery, director of the UCSF Craniofacial Center at Benioff Children's Hospital Oakland, and codirector of UCSF's Center for Advanced 3D+ Technologies, he is at the forefront of developing new tools that will expand what's possible–not only in craniofacial surgery but other disciplines as well.

Model Techniques

To describe what it's like to perform reconstructive surgery on a child's face,



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Sterilizable, 3D-printed models aid precision in surgery.

Lin uses the example of repairing a shattered egg under a blanket. The pieces are fragile, delicate, and must be painstakingly guided into place and secured with tiny plates and screws. To make this even more difficult, the surgeon must do this under the "blanket" of skin, muscle, and fat, making only minute incisions in places that will be hidden and avoid additional damage.

Until recently, the tool used to inform this painstaking process was the CT scan, which provides images of a section of the body, layer by layer, to help to diagnose the extent and location of an injury. However, surgeons dealing with spherical anatomy such as the head or heart need the detailed anatomical understanding that only a three-dimensional object can provide.

That's where 3D printing comes in. Lin was among the pioneers who helped develop and apply sterilizable, 3D-printed anatomical models–life-size, patient-specific tools that surgeons can examine, handle, and even bring into the operating room–to guide complex procedures with greater precision. For example, an engineer can print out a model of a child's skull that shows every broken bone and then print a second version where the bones are virtually fixed. Once sterilized, this model can be used as an aid in the operating room.

"Let's say all the bones around the eye socket are shattered," explains Lin. "On a model of the virtually repaired bones, I can bend plates and screws to achieve the exact contour of the repaired bones. Then I can make a tiny incision under the child's eye and slide the plate in and screw the bones to it. It's like having X-ray vision, so I no longer need large incisions to expose and see the bones. The incisions can be smaller yet the model makes the surgery more accurate. And surgery can be faster, which is essential for children because kids can lose a lot of blood during surgery, and they don't have a lot of blood to start with."

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Unique Solutions for Difficult Problems

Sterilizable 3D printing has applications beyond plates and screws. Surgeons have ordered life-size models of actual donor organs before starting transplant surgeries to ensure the organ will fit in its child recipient. A model can also create a sterilized negative guide, which is used like a stencil during surgery to allow precise cuts or to create a sterile surgical splint to show where to move the bones to the new position.

Lin describes a young patient whose jaw was shattered in a car accident. The sheer number of minuscule bone fragments made traditional repair methods like plates and screws impossible, because the bones were too small to hold screws. Instead, Lin used an existing CT scan of the child's mouth before the accident, provided by her orthodontist, to create a 3D-printed negative image of the teeth that could serve as a splint.

"Then, during surgery, the pediatric dentist [determined] which teeth were clearly shattered and had to go," he says. "I begged to keep as many teeth as possible, because then I could move the remaining teeth into the 3D-printed perfect splint, which would at least pull the bones into a better position. It was a unique solution to a difficult problem, and she's doing very well so far."

Helping Kids Have Better Lives

The sterilizable 3D-printing lab opened at UCSF's Oakland campus in October and will soon have a full-time engineer dedicated to supporting UCSF surgeons across disciplines, including plastic craniofacial surgery, cardiology, orthopedics, and neurosurgery.

Meanwhile, Lin is working with students and researchers to continue developing other new ways to advance surgery and health care. In support of such efforts, he was recently nominated to serve as the inaugural Rudney Family Endowed Professorship in Craniofacial, Maxillofacial, and Pediatric Plastic Surgery Innovations.

One of the technologies on the horizon is a tool to accurately measure blood loss in the operating room so surgeons can determine how much supplementary blood is needed–a decision that is currently based largely on guesswork. Lin, who also holds a master of business administration degree with a focus on innovation, is working on an AI-equipped speech biopsy tool that will detect subtle speech difficulties in children born with cleft palates so the problem can be remedied earlier in development.

"We're working in a lot of spaces and hoping these [technologies] will make a huge difference in health care," Lin says. "I can't stop thinking about how to help kids and their families have better lives." ■

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