

Medical 3D Printing for Improved Preoperative Planning

New technologies enable fast, affordable access to patient-specific 3D models.

WHITE PAPER

When preparing for surgery, surgeons for many years have preplanned their strategies by looking at 2D images of the surgery site. However, 2D images such as X-rays, MRIs, ultrasounds and CT scans are limited in the amount and precision of detail they can provide. This is especially true for complex anatomies and pathologies where the condition, injury or body part is extremely hard to conceptualize using conventional imaging.

Because no two injuries or pathologies are alike, a lack of patient-specific detail can lead to surprises in surgery that not only extend operating times and increase costs but lead to increased risk of infection, longer patient recoveries and, overall, suboptimal health outcomes. Furthermore, relying on 2D images for patient education and gaining informed consent is also less than ideal. It can be difficult to convey the planned approach and the severity of trauma or disease and to set patient expectations based on hard-to-understand 2D images. The truth is that most patients today are not fully informed during the consent process for this very reason.

Medical 3D printing: A breakthrough once limited by technology

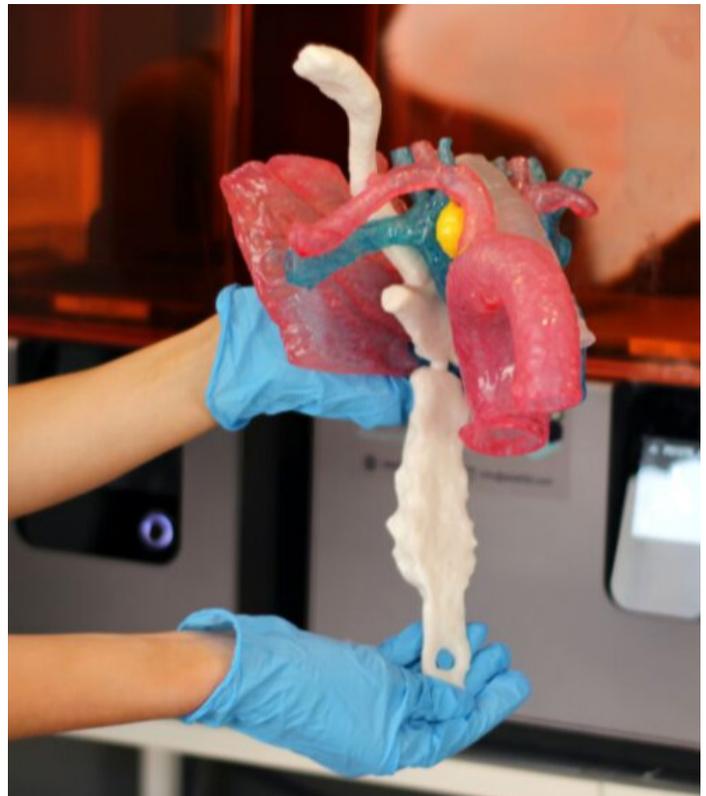
In the 1990s, biomedical engineers first tried to introduce 3D models that were detailed, patient-specific representations of patient anatomy. Quickly they realized that these models allowed surgeons to be more prepared for surgery and help patients make more informed decisions.

However, for the past 30 years, the potential of 3D modeling to improve surgical outcomes has been held back to a large degree by technology limitations. Until recently, surgeons who wanted a 3D model to work with had to have a radiologist or biomedical engineer segment an image manually. Manual segmentation typically requires four to 10 hours per model—time most clinicians can't spare. Then, even if the surgeon can get a segmented image, it has to be sent out for printing to a bureau or service provider, and it typically takes weeks, even months, to get the physical model produced at a cost of thousands of dollars. Unfortunately, these constraints largely eliminated 3D modeling as a viable option in all but a few of the most complex, non-time-critical surgeries.

Modern medical 3D printing: Accessible and affordable

Advances in technology have made medical 3D modeling much more readily available to radiology teams and surgeons around the world. Today, clinicians can use companies such as Axial3D to create patient-specific 3D models that are exact anatomical replicas from 2D patient scans.

These replicas can be held, shown to patients and their families, and used for preoperative planning, simulation and collaboration. The new technologies make 3D modeling available for surgical planning in orthopedics, traumatology, cardiology and cardiac surgery, neurosurgery, oncology, ENT and more.



Using Axial3D technology to create a 3D model is fast, easy, affordable and compliant.

How it Works

Using Axial3D technology to create a 3D model is fast, easy, affordable and compliant. To print a model, a clinician only has to upload a 2D image via the Axial3D secure online ordering platform.

No software or technology needs to be deployed at the hospital. Because no integration of any kind is required and no personally identifiable data is transmitted, there are no typical information governance and compliance concerns with using the online system. For an extra layer of security, images are retained in compliant storage, even though regulations do not require it.

Once an image is uploaded to the Axial3D platform on Amazon Web Services (AWS), depending on the pathology, the appropriate anatomical algorithm segments the image almost instantaneously. The Axial3D application extracts the relevant anatomy and reconstructs the image into a detailed, micromillimeter-

precise 3D model. The model can be printed on an in-house hospital 3D printer or externally printed and shipped in as few as 48 hours from Axial3D's Chicago or Belfast, U.K., locations. With a sub-one-hour segmentation turnaround time, medical 3D modeling can be used for even the most time-critical emergency cases.

Hosted by secure AWS

The Axial3D platform is hosted in the cloud by AWS. AWS technology removes many of the barriers to 3D medical model printing by providing a fast, affordable way for clinicians to print or print and ship models without the need to deploy any new software, networks or hardware in the hospital. The AWS cloud is highly secure and fully supports applications that store, process and transmit sensitive health data in compliance with regulations such as HIPAA and FedRAMP and international standards.

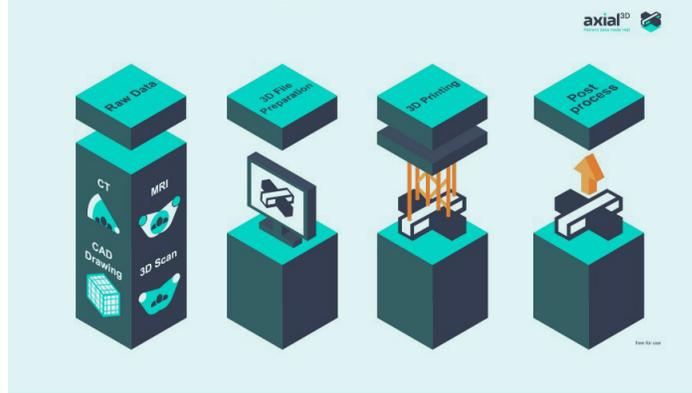
AWS is used successfully by thousands of enterprises and others that must comply with stringent healthcare regulations, including Novartis, Pfizer, Harvard Medical School, the U.S. Department of State and the U.S. Department of Agriculture. AWS is massively scalable on a global level, so there will never be concerns about running out of storage, processing power or bandwidth.

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Axial3D benefits and real-world applications

3D models are helping surgeons and their patients the world over. Used as part of the patient care pathway, medical 3D printing can lead to higher patient conversions, dramatically more accurate surgical planning, reduced operating room time, increased consent rates, transformed patient education and health outcomes, and significantly lower costs, among other benefits.

Medical 3D Printing Process



Convert more patients

In cases where pathologies are complex and variable, 3D models can prove to be extremely valuable tools surgeons can use to help fully explain the extent of a patient's pathology, discuss clinical plans and gain patient consent.¹ The improved confidence provided by 3D modeling typically leads to a 34% increase in patients agreeing to proceed with an operation where they previously would not have consented.

Support more effective surgery planning

In a recent study, 64.2% of surgeons said using a 3D model improved their understanding of a clinical situation and was more helpful than just looking at a scan. For example, one surgical team used Axial3D to create a 3D model to help plan complex surgery to repair a brain aneurysm.²

The team also requested an elastic hollow model to allow a flow test and practice the procedure. Using the models, the team was able to preselect the appropriate stent before surgery, which resulted in significant cost savings for the hospital system. Typically, having the ability to preselect the right stent before surgery can save approximately \$13,000 for each stent. Ultimately, using the model, the team successfully placed a stent and coil into a difficult area without rupture.

¹ "3D Printed Anatomical Model Supports Informed Patient Consent Ahead of Meningioma Surgery," Axial3D blog

² "3D Printed Aneurysm Model Used to Practice Procedure and Pre-select Equipment Before Surgery," Axial3D blog

Reduce time in operating room

Surgeons have found that by using 3D models in planning, they save an average of 62 minutes of operative time per case, equating to \$3,720 in surgery costs.³ These efficiency savings support increased surgical throughput while enhancing patient outcomes.

Gain informed consent

One of the most significant benefits of using a 3D model is patient education. Nearly 83% of surgeons who used a 3D model said it was extremely helpful in gaining informed consent and helping patients understand the pathology. Meanwhile, patients in 98% of cases felt that an Axial3D model was a great improvement to discussions with their surgeon.

Enable surgical plan verification

After using a 3D model in surgical planning, 46.7% of surgeons in the study completely changed their approach to the planned surgery, changed the size or type of hardware to use, or changed the type of surgery or intervention. In one example, a surgeon used a 3D model to plan the exact cutting planes and screw and plate selections ahead of a surgery to repair a child's collarbone abnormality. Having the ability to adapt the instruments in advance resulted in much higher compatibility and reduced operative time, while giving the patient a dramatically improved surgical experience.

Make informed go/no-go decisions

Recently a pediatric patient presented with multiple pathologies, including DORV, TGA, multiple VSDs and PA banding. The clinician requested an Axial3D anatomical model to help him fully understand the size of the perimembranous VSD and its relationship to the pulmonary artery origin. Because of the complexities of the case, the 3D model proved valuable in educating the family and supporting the discussion around why surgery would not be possible.

Reduce surgical planning time

A team of surgeons used an Axial3D model for planning to repair complex and extensive facial trauma. Preplanning with the 3D model saved the team 60 minutes in the operating room, resulted in less-invasive surgery, reduced complications and reduced the patient's time in care.

Tackle COVID-19 backlog

3D anatomical models are helping surgeons reduce time in planning and procedure and are giving clinicians the world's first insights into the lungs of COVID-19 patients.⁴

Conclusion

Medical 3D printing for transforming surgical planning is ready to come of age. 3D modeling can help surgeons make better, faster, more precise critical decisions, be more prepared for surgery, increase surgical throughput and transform the process of informed patient consent.

In the past, expensive and inaccessible 3D printing technology was a huge barrier to access: 3D printing was labor intensive, prohibitively slow and expensive. Leveraging the secure AWS public cloud, Axial3D enables surgeons to upload 2D scans to an application that instantly segments images and creates a patient-specific model of relevant anatomy at minimal cost. 3D models can be printed off site and sent to the clinician in as little as 48 hours or printed on site directly at the point of care.

Axial3D models can save time in surgical planning and in operating rooms, reduce costs and surgical risks, and improve patient education and outcomes. Surgeons and healthcare professionals can register for a free account and request their first 3D anatomical model at no charge at axial3d.com/try.

³ "Research Finds Use of 3D-Printed Anatomical Models in Surgery Significantly Reduces Operative Time," Axial3D blog

⁴ "Axial3D Gives a World-First Insight into the Lungs of a COVID-19 Patient with 3D Printing," Axial3D blog