Digital Anatomy Printing for Additive Manufacturing:

A Guide to Creating Accurate Anatomical Models

Additive Manufacturing,

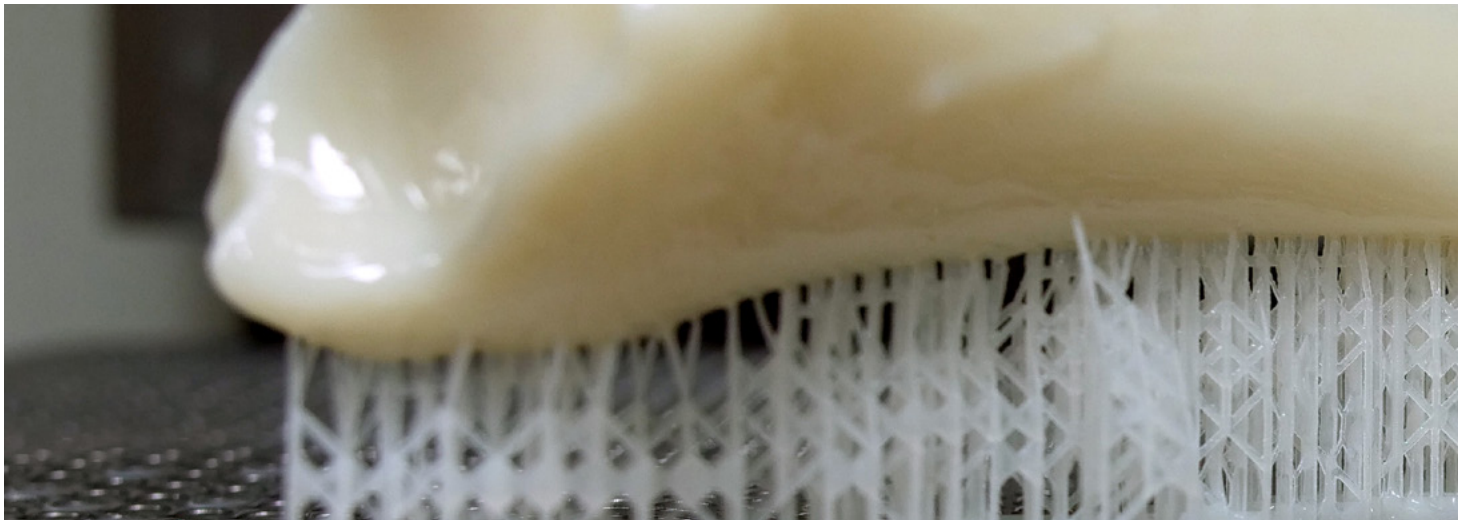
or 3D printing, has revolutionized the field of medicine in recent years, particularly in the production of anatomical models for medical applications. These models are used in surgical planning, medical education, and research. They provide an accurate representation of anatomy and allow surgeons to plan procedures, test surgical approaches, and enhance understanding of their patients.

Digital anatomy printing (DAP) involves the use of 3D printing technology to create anatomical models from digital data, such as CT scans or MRI images. This technology allows for the creation of patient-specific models that are an exact representation of the patient's anatomy. This level of accuracy and precision is critical for medical applications, as it allows for better surgical planning and reduces the risk of complications during surgery.

The creation of digital anatomical models involves several steps, including selecting the appropriate materials, choosing the right printing technology, post-processing, and ensuring regulatory compliance. Additionally, customization and personalization of the anatomical models are critical for their successful use in medical applications.

In this eBook, we will explore these various aspects of additive manufacturing and will examine case studies from real-world jobs produced by the team at ADDMAN and Dinsmore.

Table of Contents



01 The Art of Precision in Digital Anatomy Printing

Contract manufacturers work closely with their clients to ensure the accuracy of anatomical models. To achieve this, they follow a detailed process that includes several tools and quality assurance measures.

The first step is for the client to provide the service provider with the necessary files. These files typically include medical imaging scans and are used to create a 3D model of the anatomy. Additive technicians then use specialized software such as 3D modeling software or computer-aided design (CAD) software to transform these files into a digital model of the anatomy.

Once the digital model is complete, the manufacturer creates a physical model using a variety of manufacturing processes such as 3D printing or even CNC machining. The physical model is then carefully inspected to ensure it matches the digital model, and any discrepancies are corrected.

Quality assurance is an essential final step of any manufacturing process.

Print shops use a range of tools and techniques to ensure the integrity of the final product. These may include measurement tools such as calipers and micrometers, as well as inspection tools such as visual inspection and X-ray analysis.

To ensure the print is exact, it is common to work closely with medical professionals such as surgeons or radiologists. These professionals can provide valuable feedback on the accuracy and functionality of the model, and help ensure that it meets the needs of the end user.

Overall, contract manufacturers use a combination of advanced software, specialized manufacturing techniques, and quality assurance measures to create accurate and high-quality anatomical models for their clients. By working closely with their clients and utilizing the latest tools and techniques, they can create models that are tailored to the specific needs of medical professionals and researchers.

02 Dissecting the Anatomy of Common Materials

Understanding the Properties and Benefits of Different Printing Materials

Selecting the right material for 3D printing anatomical models is crucial for their successful use in medical applications. One should choose materials that are biocompatible, safe, and meet the necessary medical standards. The choice of material will depend on the intended use of the model, with different materials having different properties such as strength, flexibility, and durability.

Common Materials Used for 3D Printed Anatomical Models

Acrylonitrile butadiene styrene (ABS):
This is a strong and durable polymer commonly used in fused deposition modeling (FDM) technology, making it ideal for producing robust digital anatomy prints that can withstand frequent handling or use.

Polyvinyl alcohol (PVA):
PVA is a water-soluble polymer often used as a support material for complex digital anatomy prints, as it dissolves easily and leaves no residue behind.

Nylon:
Nylon is a strong and flexible polymer that can produce digital anatomy prints with high tensile strength, making it suitable for creating models of anatomical structures that require flexibility, such as joints or ligaments.

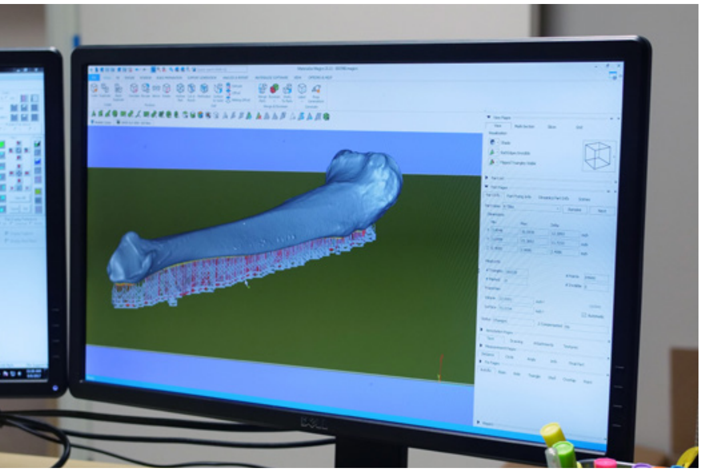
Polylactic acid (PLA):
PLA is a biodegradable polymer that offers high-resolution printing capabilities, making it a popular choice for creating detailed digital anatomy prints. It is commonly used in stereolithography (SLA) and digital light processing (DLP) technology.

Polyethylene terephthalate glycol (PETG):
PETG is a transparent and strong polymer that is commonly used to produce clear digital anatomy prints, making it an ideal material for creating models of transparent anatomical structures, such as blood vessels or the digestive system.

With 3D printing, when you pair the proper material with the right polymer additive manufacturing methodology, it can be adapted to mimic bone or tissue structure deviations throughout the human or animal anatomy. This is especially helpful for surgical aids when the amount of pressure or point of entry is critical.

03

The Technology Landscape



Exploring the Advantages of Printing Technologies

There are several printing technologies available for creating digital anatomy prints, each with its own advantages of having in our arsenal to support clients.

Users of anatomy prints and their manufacturing partners need to consider the intended use of the model, the required resolution and accuracy, as well as cost and time constraints when selecting a printing technology. Understanding the merits and intricacies of each printing technology is crucial for selecting the right one for the intended use of the model.

Affordable Strength: For high-use parts, Dinsmore and ADDMAN clients can make use of our CAAM (computer aided additive manufacturing) methodology and InterFill 3D software solution. This option unlocks 100x stronger parts via FDM process and renders legacy slicing techniques obsolete.

Fused Deposition Modeling (FDM):
is a popular printing technology that uses melted thermoplastic filaments to create layer-by-layer prints. FDM is a cost-effective and fast printing method, but its resolution and accuracy may not be as high as other printing technologies.

Stereolithography (SLA):
uses a liquid resin that is cured by a laser to create precise and accurate prints. SLA produces high-resolution prints with smooth surface finishes but can be more expensive and slower than FDM.

Selective Laser Sintering (SLS):
uses a laser to fuse powdered materials, such as nylon or metal, to create strong and durable prints. SLS is ideal for creating anatomical models with complex geometries and can produce high-quality prints with accuracy, but it is also one of the most expensive printing methods.

Polyjet: is a printing technology that uses liquid resin and UV light to create high-resolution prints with fine details and intricate geometries. PolyJet can produce multi-color prints and can create models with flexible and rigid components. However, PolyJet prints can be brittle and may require post-processing to achieve a smooth surface finish.

04 Finishing Effects

Post-processing plays a critical role in creating high-quality anatomical models that are both accurate and visually appealing. The process involves removing support structures, smoothing the surface, and ensuring that the model is free from defects. The removal of support structures is necessary because it allows for a clearer view of the model's internal structures. Smoothing the surface eliminates any rough or uneven areas, resulting in a more polished finish. Additionally, ensuring that the model is free from defects is crucial as it improves the overall accuracy of the model.

Post-processing may also involve painting or coloring the model to enhance its visual appearance. This technique can help highlight specific structures and make them more visible to the viewer. The use of colors can also help differentiate between various tissues and organs, making the model more realistic. Some of the different post-processing techniques include sanding, polishing, painting, and staining. Sanding and polishing are used to remove rough edges and create a smooth surface. Painting and staining can be used to add color and highlight specific areas of the model.

Custom coatings can be added to the interior of the model to enable users to practice procedures and improve their overall technique.

Custom coatings can be applied to mimic different textures and properties of organs, allowing for a more realistic experience during procedures. This allows users to see where mistakes were made, learn from them, and improve their skills before performing procedures on real patients.

Some of the different custom coating techniques include the application of synthetic materials or silicone to mimic the properties of tissues and organs. These coatings can be customized to replicate different textures and densities, providing a more realistic simulation for medical professionals.

By implementing these techniques, modelers can create anatomical models that are not only accurate but also visually appealing, engaging, and educational aids for the end-users.

05 Real-World Applications

How ADDMAN Group companies have improved patient outcomes with additive.

CASE STUDY:
Patient-Specific Surgical Aid with SLA Technology

CHALLENGE:

The Children's Hospital of Orange County (CHOC) collaborated with Dinsmore, Inc. to create a customized 3D model of an 18-year-old patient's deformed bone prior to surgery.

SOLUTION:

A patient suffered a tibial tubercle fracture during his youth, which resulted in a growth arrest below his kneecap and a deformity of his tibia. This type of deformity caused difficulty in daily activities such as walking or running, and significantly increased the risk of early onset arthritis. To correct it, surgeons needed to make cuts to the bone and carefully move it back to the normal position. Due to the complexity of the surgery, pediatric orthopedic surgeon, and Medical Director of the CHOC Children's Orthopedic Institute, reached out to Dinsmore to request assistance for creating a life-size 3D model of the patient's tibia.

Relying on an intra-operative assessment during the surgery would have risked the chances of a successful outcome, so having the opportunity to study an exact replica of the deformed tibia was invaluable for the surgical team.

It allowed them to visualize their moves, plan their cuts, and keep the patient and his family informed on exactly what they were going to do during the operation. For the sake of speed and accuracy, the Dinsmore team decided to use stereolithography (SLA) to produce the 3D model. After an SLA part finishes printing, the part is left in what's called a green state – and although the part has reached its final form, the polymerization reaction is not completed at this stage. The strongest mechanical properties will only be realized when exposed to a combination of light and heat.

To mimic the density and surface finish of a real bone, engineers at Dinsmore chose to cure the model in a unique way, leaving it in a semi-green state that allowed the CHOC team of surgeons to receive a realistic representation of the model.

"For complex surgeries like this one, the 3D physical model was a great conceptual practice tool for pre-surgical planning. It gave us a tactical visualization of the deformity so we could get a better sense of what needed to be done to correct it. You can measure the deformity in CT scans, but there's nothing like being able to hold the physical model."

– Surgical Team Member, CHOC

OUTCOME:

Needless to say, the surgery was a success. In only four months, the team of surgeons at CHOC were able to reset his normal gait and function – and after six months, he was able to regain the ability to walk and run without any complications.

CASE STUDY:
3D Printed Shoulder Bone for Hoag Hospital

CHALLENGE:

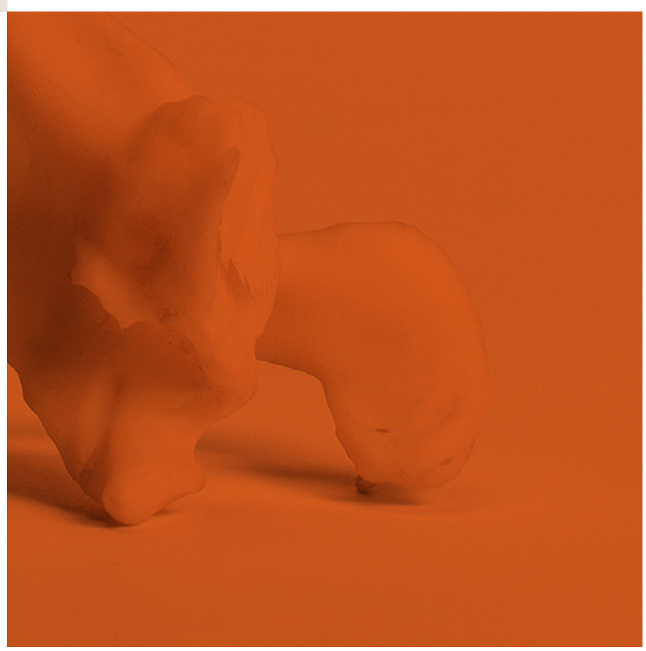
Surgeons at Hoag Hospital in Newport Beach faced a unique challenge when they needed to complete a bone graft surgery to repair a hole in a patient's shoulder blade. This surgery required precision, accuracy, and skill in a hard-to-access location, making it a daunting task even for experienced surgeons.

SOLUTION:

To help the surgical team prepare for this complex procedure, the hospital turned to our 3D printing service at Dinsmore & Associates. We were able to take the X-ray data of the patient's shoulder blade and convert it into an exact 3D model using our engineering and design expertise. Our use of the SLA process ensured high detail and accuracy in the replica, making it as close to the actual bone as possible.

OUTCOME:

With the 3D model in hand, the surgical team was able to do a trial run of the bone graft surgery, giving them the opportunity to examine the patient's bone and plan the procedure with greater precision and accuracy. The use of the 3D model helped the team achieve a successful surgery, demonstrating the value of our 3D printing service in providing doctors with the tools they need to perform complex surgeries with greater confidence and success.



Closing Thoughts

In conclusion, digital anatomy printing (DAP) using 3D printing technology has transformed the field of medicine by allowing for the creation of patient-specific anatomical models that provide an accurate representation of the patient's anatomy. The accuracy and precision of these models are critical for medical applications, as they help in surgical planning, medical education, and research, reducing the risk of complications during surgery.

The manufacturing process involves several steps, including selecting appropriate materials, choosing the right printing technology, post-processing, and ensuring regulatory compliance. With the use of advanced software, specialized manufacturing techniques, and quality assurance measures, manufacturers can create accurate and high-quality anatomical models that are tailored to the specific needs of medical professionals and researchers. The technology landscape offers various printing technologies and materials to choose from, with each having its own advantages, enabling us to create models that save lives.

Bring Anatomy to Life with Precision-Crafted Polymer 3D Prints

At ADDMAN, we are committed to excellence in every aspect of our business. We strive to provide the highest-quality products and services, ensuring that your journey towards efficient and effective medical tools is a success.

If you're ready to take your manufacturing process to the next level, trust ADDMAN to help you achieve your goals.

Contact us today to learn more.

addmangroup.com

info@addmangroup.com

DINSMORE AN ADDMAN GROUP COMPANY

HARBEC AN ADDMAN GROUP COMPANY

CASTHEON AN ADDMAN GROUP COMPANY