Metalworking

How Additive Manufacturing Is Revolutionizing Medical Implants

Kip Hanson | Feb 11, 2025

Of all the products that additive manufacturing is used to create, medical implants may be the ones for which it's most uniquely qualified.

That's because the system, more commonly known as ***3D printing***, specializes in forming complex shapes like those found in hip bones and ear canals—shapes that are difficult and sometimes impossible to generate on CNC machine tools.

But wait: Mill-turn lathes and ***5-axis machining centers*** routinely cut these shapes and more, right? Just look at the turbine blades and blisks used in jet engines or the hugely complex geometries seen in many plastic injection molds. Surely these are every bit as difficult to machine as a replacement for Grandma's knee, right?

Capabilities That CNC Machines Can't Mimic

Maybe not. Even though medical manufacturers continue to machine ***the lion's share of all devices and implants***, additive manufacturing brings some special capabilities to the table that CNC machinery will never mimic.

Chief among these is enhanced osseointegration, defined as the process of bone growing into and around a metal implant.

For example, a study in the World Journal of Orthopedics ***reported*** in 2023 that "the use of a highly porous titanium implant, manufactured with 3D printing … provides increased osseointegration compared to a plasma-coated [the conventional alternative for machined parts] titanium implant."

Granted, the study was conducted on lab rats, although the Royal National Orthopaedic Hospital of London notes that 3D-printed acetabular cups, used in hip replacement, are commercially available.

“We’re in the middle of a revolution in orthopedics with the adoption of additive manufacturing (3D printing) methods to produce titanium hip, knee and spine implants,” the hospital says. “The clinical rationale is clear: enhanced bony fixation and the ability to fully customize an implant to a patient.”

This revolution is due to additive manufacturing’s ability to print what can best be described as sponge-like structures, which greatly increase the surface area of bone-to-metal interfaces.

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And unlike machined implants, where cycle times and production costs alike increase with every cubic inch of metal removed, 3D printing is just the opposite: Less metal equates to shorter build times, lower costs, and lighter weight, an important factor for many medical components.

Custom Fitting of Medical Implants

The use of additive manufacturing in its many forms also equates to more personalized healthcare. Since it’s relatively straightforward to convert a patient’s MRI or CT-scanned images into a 3D CAD model that a technician can then use to reverse-engineer a customized implant, medical manufacturers like Belgium-based Materialise use the process to produce all manner of patient-specific guides, implants and medical tools.

“Our goal is to realize mass personalization in healthcare, and we recently celebrated our 600,000th patient treated toward that objective, a threshold that took us a couple of decades to cross,” ***says*** Todd Pietila, director of medical sales for the Americas and EMEA at the company’s North American headquarters and production hub in Plymouth, Michigan.

What does all this mean for manufacturers? For starters, it creates a significant opportunity.

As The Business Research Co. predicts in its ***3D Printed Medical Devices Global Market Report 2025***, the market size is expected to grow 18 percent a year through 2029, taking its value to $7.79 billion.

Additive Manufacturing Techniques

Much of that growth is expected in metal additive manufacturing, which relies heavily on laser powder bed fusion (L-PBF). As its name suggests, this technology employs a laser to fuse tiny bits of titanium and other alloys, building parts from the bottom up, one layer at a time, in a bed of metal powder.

Laser powder bed fusion and related metal printing technologies such as binder jetting and direct energy deposition (DED) are increasingly relied on to produce medical components.

These include acetabular cups, not to mention knee implants, cranial plates, dental crowns, spinal fusion cages and much more.

But don’t discount polymers. Since metal printers are more expensive than those used to produce plastic parts—stereolithography (SLA), fused deposition modeling (FDM), selective laser sintering (SLS), and digital light processing (DLP), to name a few—small shops and newcomers to the medical space might opt to start by investing in one of those lower-cost systems.

That helps explain why medical facilities like the 3D Innovations Lab at ***Rady Children’s Hospital*** and the Mayo Clinic’s ***3D Anatomic Modeling Laboratory*** print everything from patient-customized surgical guides to 3D anatomical models for planning and education. That said, many hospitals, clinics, and smaller medical facilities rely on external service providers due to cost, expertise and regulatory compliance.

After the Print

Remember that all additive production methods require some level of post-processing. For many plastic parts, that step is often no more than a quick tumble in a vibratory finisher or a few minutes in a vapor polishing machine.

Those with threaded features, close tolerances and sharp edges, however, will require finish machining.

And considering that medical manufacturers utilize PEEK and ULTEM for many parts, shops should be prepared to invest in high-quality carbide tools and develop the proper machining knowledge to cut the tough, abrasive polymers.

Metal parts also require finish machining. This begins with cutting them away from the build plate, usually with ***wire EDM***, followed by the removal of support structures common with L-PBF parts.

Since most parts are made of biocompatible, corrosion-resistant materials like titanium, cobalt chrome alloys, austenitic (300-series) stainless steels or even super-hard ***refractory elements*** like tantalum and tungsten, shops must be prepared to finish-machine critical features and close-tolerance holes and mounting surfaces.

Fortunately, many machine shops already have extensive experience with these metals due to decades of work in the aerospace, medical and energy sectors. What perhaps is most challenging is the workholding. Imagine clamping onto a part shaped like a human cranial implant, a delicate bone scaffold, or a soft, squishy gripper for a medical robot?

Lastly, don't forget that the medical industry is highly regulated. Machine shops and 3D printing houses that work in it must be prepared to achieve 510(k) approval from the U.S. Food and Drug Administration, a process that can take years.

With that come requirements for ongoing process control, strict cleanliness and compliance challenges, and, for those who wish to embrace additive manufacturing, muscling through a steep, expensive learning curve.

Which additive manufacturing techniques has your shop used? Tell us in the comments below.

