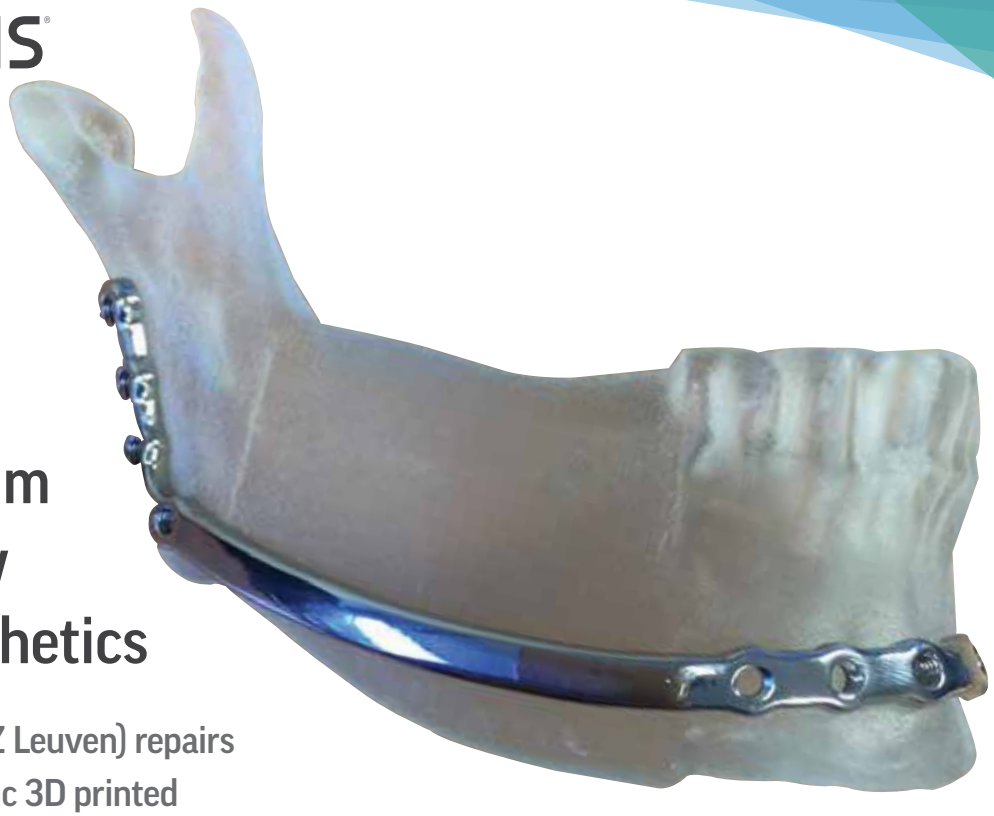
3D SYSTEMS



# 3D Printed Titanium Plate Restores Jaw Function and Aesthetics

## University Hospitals Leuven (UZ Leuven) repairs jaw fracture with patient-specific 3D printed titanium reconstruction plate from 3D Systems

*3D Systems produced the Titanium reconstruction plate using metal 3D printing.*

Sam couldn't catch a break. After surgery to remove a kidney tumor, Sam (63) diligently followed doctor's orders and took the medications he was prescribed to prevent malignancies from spreading to his bones and maintain normal blood calcium levels. Unfortunately for Sam, more challenges were yet to come in the form of side effects. The anti-bone resorbing agents in his medication jeopardized normal bone regeneration and introduced a difficult condition known as Medication Related Osteonecrosis of the Jaws (MRONJ). This condition adversely affects the bone's ability to heal or cope with infections and trauma.

Regrettably, Sam soon presented with a localized bone infection in his jaw, which was aggravated by osteonecrosis (the dying off of bone tissue due to lack of blood supply). The death of this bone led to a pathological pre-angular mandibular fracture on the right side that was accompanied by osteomyelitis, or inflammation of the bone, and the formation of an abscess, loss of sensitivity in the lower jaw and lip, intense pain and extreme limitation of jaw movement.

**Finding the best jaw surgery solution**

Sam needed help. By now he had a gaping hole in the middle of his right lower jawbone, causing him daily pain and discomfort. Sam's doctors at University Hospitals Leuven (UZ Leuven) had a lot to balance as they mapped out the best possible course of treatment. Although the anti-bone resorbing agents negatively impacted bone healing, they fortunately did not affect Sam's soft tissue healing. Nevertheless, Prof. Dr. Joseph Schoenaers, Prof. Dr. Constantinus

**CHALLENGE:**
Manufacture a precise jaw reconstruction plate with optimal screw placement to safeguard against material fatigue fracture in the bridging area

**SOLUTION:**
Patient-specific reconstruction plate 3D printed on a ProX® DMP 320 printer in LaserForm® Ti Gr23 (A) titanium, finished, and machined by 3D Systems' additive manufacturing experts

**RESULTS:**

- Optimized screw hole placement allowed the surgical team to keep the force bearing plate as solid as possible to withstand loading
- 3D Systems LaserForm® titanium material is biocompatible and suitable for milling
- 3D inspection of manufactured part prior to delivery eliminates guesswork and contributes to a more streamlined operation

*"Because of 3D printing, the patient-specific reconstruction plate fit snugly, and all of the bone segments and dental arches were in their exact pre-defined position."*

*— Dr. Yi Sun, UZ Leuven*

Politis and Dr. Yi Sun preferred a treatment that enabled them to safeguard the pre-existing occlusion and avoid the donor site morbidity that occurs with autografts. Sam's doctors proposed removing the remaining piece of jawbone in the fracture area and restoring the continuity of his jaw with a patient-specific reconstruction plate that was made to measure.

For help achieving a precision fit on this patient-specific part, the medical team reached out to 3D Systems. Using patient-specific imaging data, 3D Systems' Healthcare team is able to create accurate digital 3D anatomical models that can be used for a number of surgical planning, design and manufacturing outputs. In Sam's case, the medical team at UZ Leuven needed help identifying the optimal production process and workflow for Sam's reconstruction, as well as help bringing those plans to life through production. "We selected 3D Systems because it is a leading 3D printing company," said Dr. Sun. "It was also helpful in our case that 3D Systems has a local presence near the UZ (University Hospital) here in Leuven and it was able to offer a made-to-measure part to the patient affordably."

**Designing a precision jaw reconstruction plate**

Without a 3D workflow and the technology and support of 3D Systems, the alternative path to treatment would have involved bending a standard bridging reconstruction plate by hand until it approximated the desired form. However, with this conventional approach there would be no way to optimize the placement of the screw holes or harmonize screw hole placement with the rest of the reconstruction plate design, which could weaken the plate's resistance to material fatigue fracture in the bridging area.

"Control over screw hole placement was of decisive importance in this case because the patient's body no longer has the means to repair the bone, as is needed for the stable bio-integration of the screws, even with the use of an osteo-myo-cutaneous flap," said Dr. Sun. "In jaw surgery there is no room for the slightest amount of malocclusion, so the 3D reconstruction had to be perfect, and the force bearing plate had to be as solid as possible to withstand the loading. That would not have been possible to the same extent without a 3D printing approach."

*Cutting guides 3D printed by UZ Leuven give precise instructions on how to remove the remaining piece of jaw bone.*

Once 3D Systems had been selected to assist Sam's surgeons, two engineers from 3D Systems' Healthcare team were assigned to the case and accompanied the entire procedure, from planning all the way to the operating room. After Sam's medical imaging data had been transformed into a three-dimensional digital model, UZ Leuven printed a physical anatomical model of the jawbone in separate components using the 3D printer housed in their lab. Together these plastic jaw components were used to format the surgical cutting guide and design the reconstruction plate.

The 3D printed cutting guide allowed the surgeons to smoothly transfer their surgical plan into the operating room and precisely remove the remaining piece of jawbone. Prof. Dr. Schoenaers and Dr. Sun also designed the reconstruction plate, and provided the 3D design to 3D Systems for production and finishing as specified.

The medical team also used their early 3D printed anatomical models to pre-determine the placement and position of the screw holes. Screw holes for these types of reconstructive plates are typically located where the jawbone is the thickest and strongest, which means they should align as much as possible with the posterior cortical bone-edge of the ascending ramus of the lower jaw. To accommodate this ideal placement, multiple screws were required at different orientations. To ensure the screw threads were as sharp and accurate as possible, the final 3D printed reconstruction plate was milled as part of post-processing.

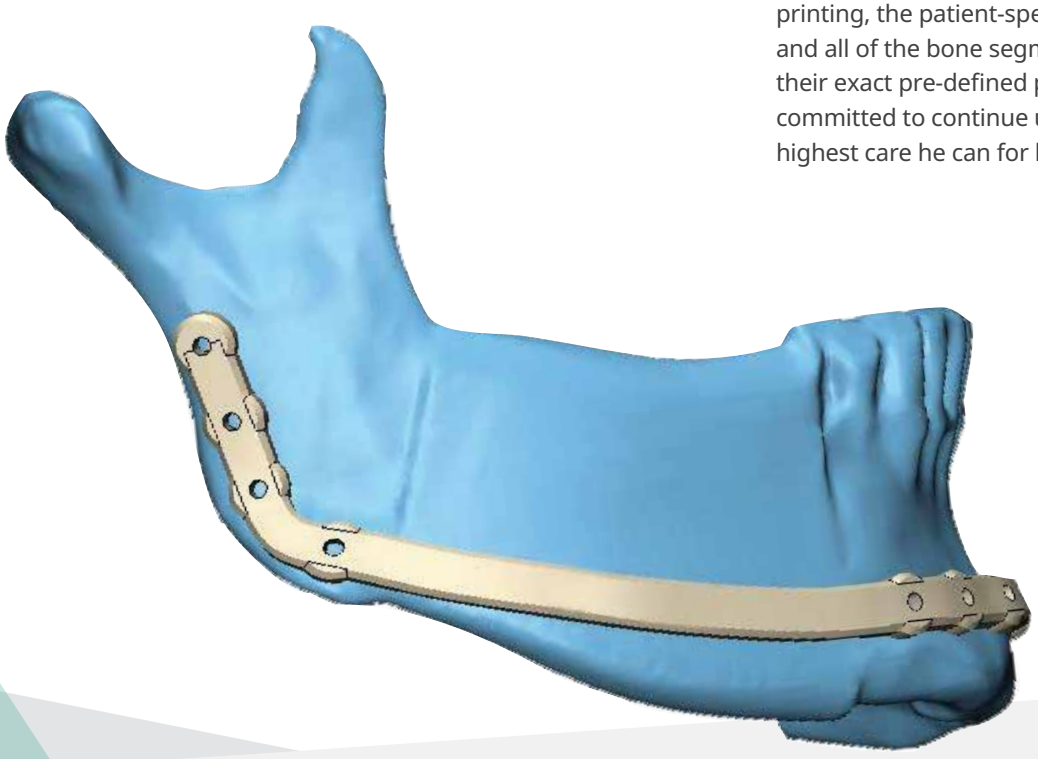
**3D printing and inspecting for an ideal fit**

After the doctors had designed the reconstruction plate, all of the measurement data was saved in an STL file and sent to 3D Systems for preparation and printing in titanium using a ProX® DMP 320. 3D Systems' LaserForm® Ti Gr23 (A) titanium material is a pure metal that is biocompatible and suitable for milling. The final thickness of the reconstruction plate was 3 millimeters, which Sam's doctors selected for its strength and ability to perfectly camouflage beneath Sam's muscle and subcutaneous tissue.

After the reconstruction plate had been printed, finished and milled, it was 3D scanned to compare the final physical part with the original design specifications. This step ensured correct dimensions and feature placements to avoid having the plate not fit or fail to install as expected in the operating room. The standard titanium screws that would be used on surgery day were also checked to verify their exact fit into the drilled thread holes.

When it was finally surgery day, Sam's doctors brought in the plastic 3D printed models for reference. "Once an incision is made, visibility is quickly compromised," said Dr. Sun. "Being able to refer to the planning models without obstruction was a big help." The surgery went precisely according to plan, and both the function and aesthetic of Sam's jaw have been restored. Furthermore, Sam's hospital stay was limited to one day and only a faint scar is left as he continues to heal.

Dr. Sun is pleased with Sam's outcome: "Because of 3D printing, the patient-specific reconstruction plate fit snugly, and all of the bone segments and dental arches were in their exact pre-defined position," he says. Dr. Sun says he is committed to continue using 3D technologies to deliver the highest care he can for his patients.



*UZ Leuven created a digital model of the patient's jaw to model the reconstruction plate.*

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