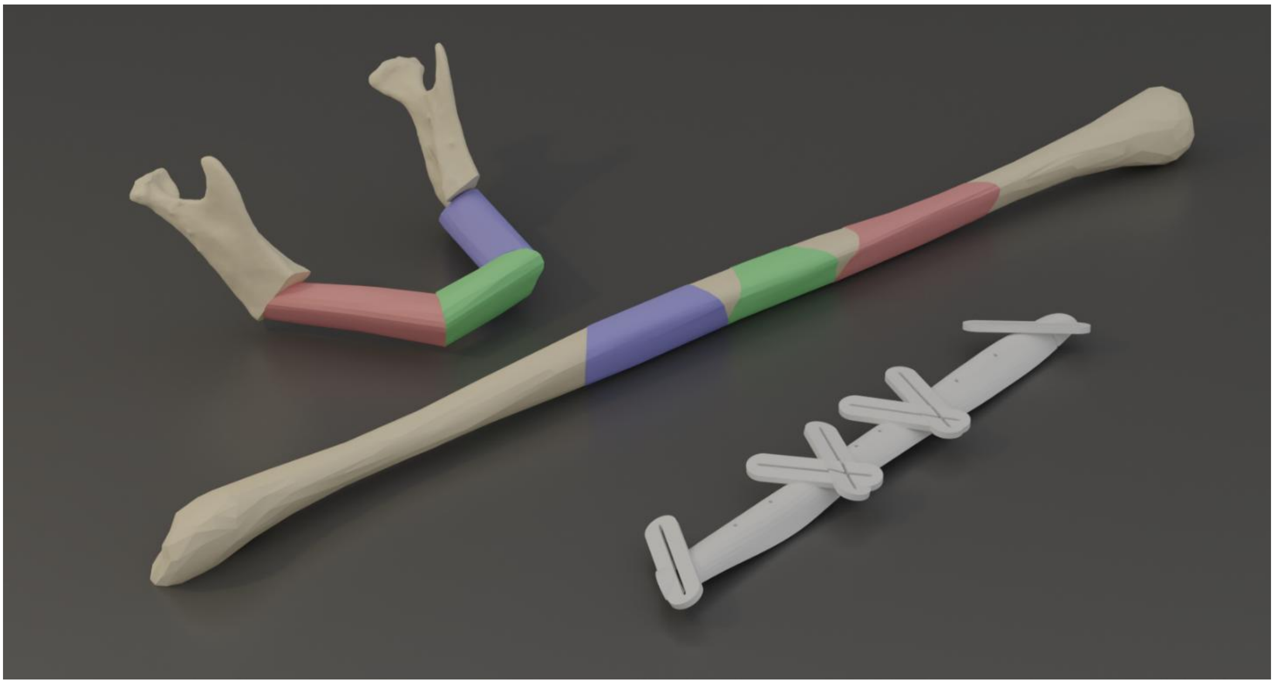
AI and 3D printing in medical technology

Individual facial reconstruction

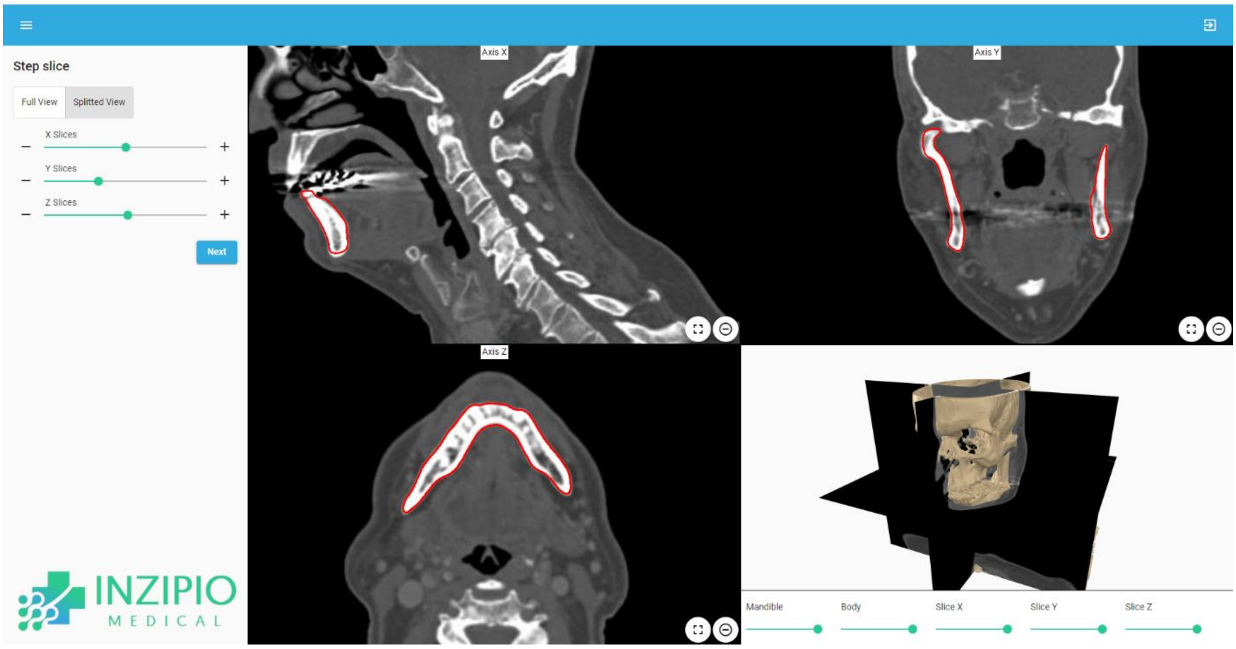
(A technical article from 2022, author Max Wissing, Technology Manager Additive Manufacturing, Protiq GmbH, Blomberg)



If there is a large bone defect in the facial skull due to tumor resection in the case of inflammatory diseases (e.g. osteomyelitis) or trauma (e.g. war injuries or traffic accidents), this requires complex bony and soft tissue reconstruction.
The combination of artificial intelligence and 3D printing enables complex operations to restore the jaw using the body's own microvascular fibula graft. (Source: Inzipio)

Additive manufacturing, usually known as 3D printing, has been gaining in visibility and importance for years. While the technology was initially used primarily for optical models and the rapid creation of prototypes, 3D-printed components now perform a wide range of tasks in a large bandwidth of fields - including medical technology.

Today, users can choose from numerous additive manufacturing processes and materials. Components can be made from engineering plastics, high-strength metals or exotic materials such as medical silicone and quartz glass. What all additive manufacturing processes have in common is that the components are built up layer by layer by adding material. Unlike many conventional production technologies - such as turning, milling or eroding - material is not removed but added in a targeted manner. This is why additive manufacturing processes are characterized by a high degree of design freedom and flexibility.



Inzipio uses artificial intelligence to automatically process CT data into 3D data. This enables complete digital surgical planning, making even complex reconstructions possible. (Source: Inzipio)

The components can be produced directly from the designer's 3D data and individually adapted to the respective application. In combination with the fast and economical production of small quantities, this flexibility makes additive manufacturing the method of choice for medical applications in particular.

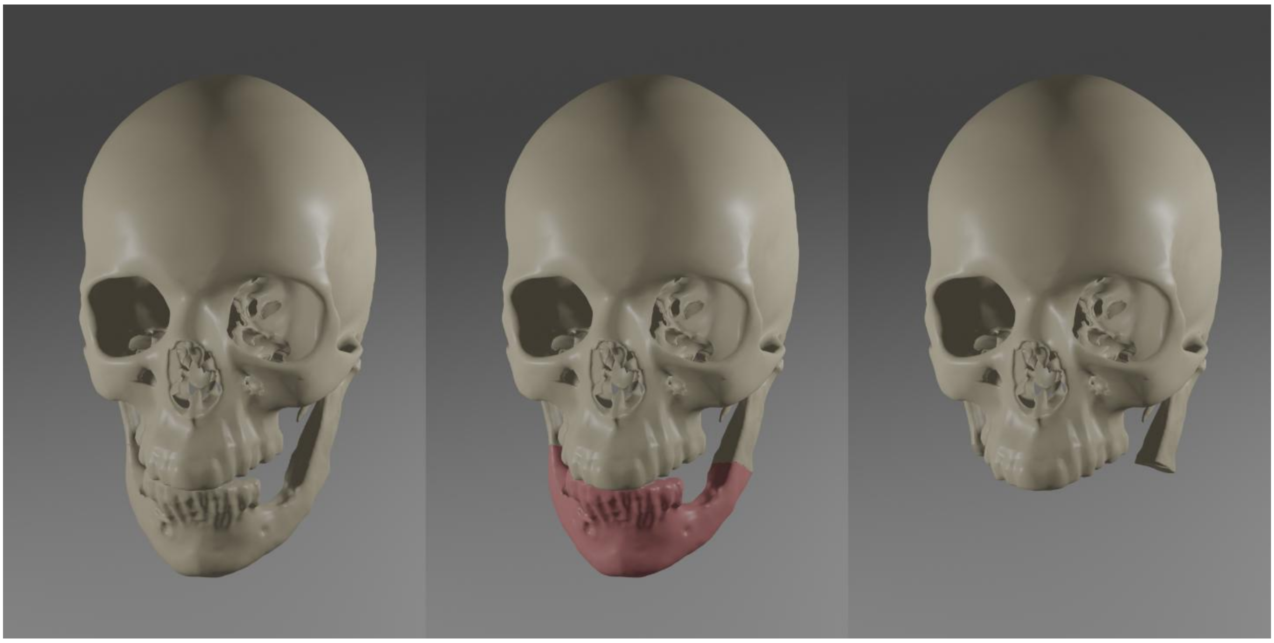
The components can be customized to the shape and needs of the patient, which is beneficial for both the patient and the doctors treating them.
Well-known applications on and in the body include specially adapted orthopaedic splints made of plastic, dental crowns made of stainless steel and general implants made of titanium.

Fast and fully digital surgical planning

In addition to the direct production of the implant, 3D-printed templates that do not remain in the body offer great added value during treatment. The collaboration between medtech start-up Inzipio and additive manufacturing service provider Protiq falls into this context. Together, the two companies have produced innovative cutting guides in the field of reconstructive facial surgery. Protiq GmbH, which is part of the Phoenix Contact Group, has more than ten years of experience in 3D printing. The service provider focuses on projects with special requirements and high quality standards. Protiq provides additively manufactured components made from a variety of established plastics and metals. At the same time, the company stands out through the active development and qualification of new, innovative materials.

As a spin-off of RWTH University Hospital Aachen, Inzipio is developing medical software that will enable the automatic planning of facial reconstruction operations through the use of artificial intelligence. With Inzipio's solution, digital 3D data can be generated from computed tomography (CT) imaging in just a few seconds. Previously, this was a time-consuming manual process that required additional clinical staff or was outsourced to external service providers.

The 3D data generated enables fast, fully digital surgical planning before the actual procedure. The time saved now benefits clinic operations and better patient care.



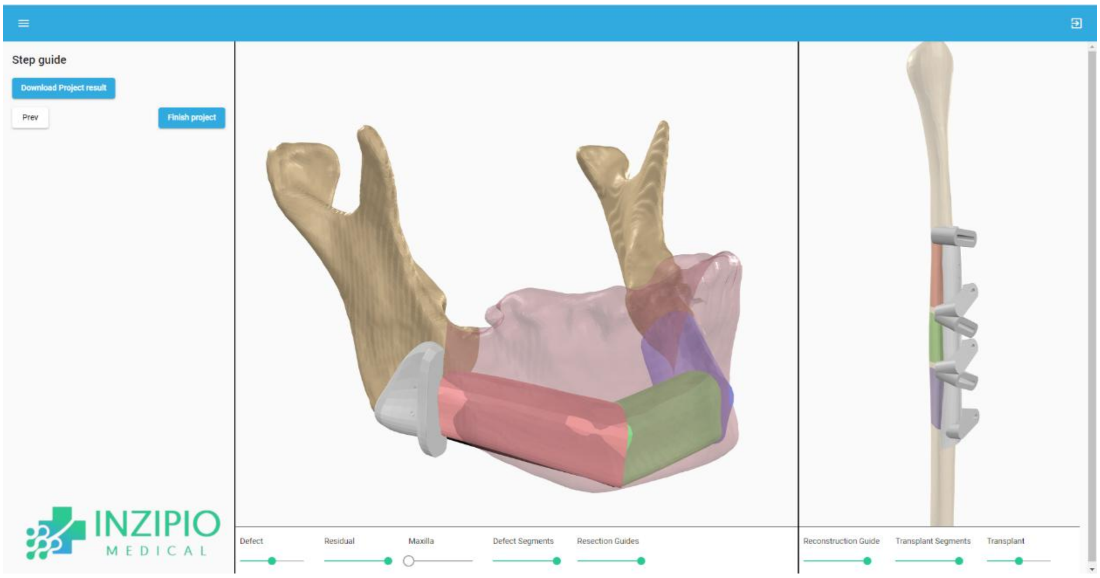
3D image of a patient with an inflamed mandible. The affected area is precisely removed before reconstruction using digitally planned and 3D-printed resection templates. (Source: Inzipio)

Precise determination of cutting angle and position

Facial surgery in particular benefits from the precision and preparation of upcoming operations. The face not only fulfills various vital functions - such as breathing and food intake - but is also closely linked to a person's identity due to the possible display of emotions. If a large part of the jawbone and soft tissue has to be removed due to a tumor or an accident, aesthetic rehabilitation becomes all the more important alongside functional rehabilitation.

To restore the upper or lower jaw, surgeons can use a so-called microvascular fibula graft. This involves replacing the jawbone with parts of the body's own fibula. The complex U-shaped geometry of the jaw can be reconstructed by segmenting the graft into several lengths and angles. In addition to the bony parts of the fibula, skin and muscles - so-called soft tissue islands - are also removed from the calf with the vessel to be connected to supply the graft. The soft tissue islands are also used to reconstruct the facial tissue lost through the resection in the best possible way.

The incision angle required for this purpose and the incision position for lifting the graft are precisely determined in the digital surgical planning. In this way, the actual procedure can be performed as quickly and efficiently as possible, which increases the chances of success of the operation. The use of the fibula as an autologous graft is particularly suitable for this type of procedure. The long tubular bone provides sufficient material for flexible segmentation of the required bone material and also has sufficient stability to restore jaw function. Patients are not significantly restricted by the missing fibula, as the tibia alone can bear the load that occurs when walking.



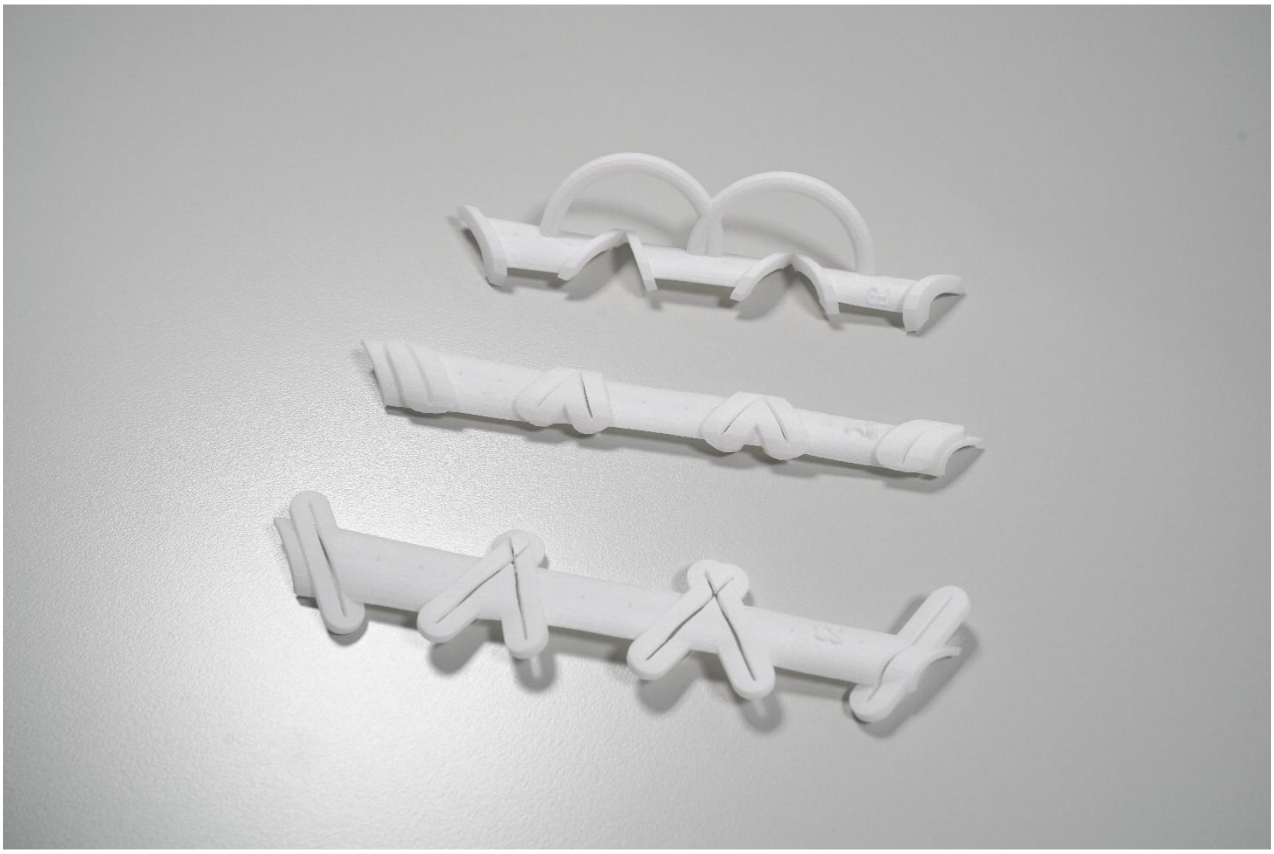
Reconstruction of the mandible using segmented microvascular fibula grafting. The use of digitally planned and 3D-printed cutting guides reduces operating time and increases precision, thus achieving a good functional and aesthetic result. (Source: Inzipio)

Additively manufactured cutting guides

Inzipio can generate patient-specific cutting guides for precise transfer of the digital planning to the surgical site. These are used both for the resection of the affected lower jaw section and for lifting the fibula graft. The cutting guides digitally planned by Inzipio can be produced by Protiq using 3D printing within a short time before the operation.

The components are made of PA12 engineering plastic, can be sterilized and meet all the necessary requirements of medical device class 1 for short-term wound contact. These cutting guides indicate the exact position of the incisions to be made, the length of the grafts to be lifted and the required cutting angle so that the jaw shape can be reconstructed as planned. A similar procedure without these aids - "freehand", so to speak - would also be possible in principle, but is limited to smaller defects.

Until the transplanted segments have successfully healed, they are screwed into place with a titanium plate to hold them in position. This is usually a standard product that is bent into shape using another 3D-printed auxiliary geometry. Alternatively, 3D-printed titanium implants can now also be used directly, which can already be digitally adapted to the patient.



The cutting guides allow the individual digital planning to be transferred as precisely as possible to the surgical site. The cutting guides allow, for example, a U-shaped reconstruction of the mandibular defect based on planned segment lengths and angles. Left: automated, digital planning; right: Protiq 3D-printed cutting guides made of PA12. (Source: Protiq)

Conclusion

The combination of digital surgical planning using artificial intelligence by Inzipio and additive manufacturing at Protiq contributes to the success and quality of reconstructive treatments. Bony microvascular grafts represent the state of the art in oral and maxillofacial surgery, but due to the complexity described above, they are only possible with the inclusion of these innovative technologies.

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Further information:
www.protiq.com

3D printing in orthopaedic footwear technology

The customization of orthopaedic shoes usually takes several weeks. A decisive time factor here is the individual production of the lasts that are used to make the shoes. This lengthy process can be significantly shortened by additive manufacturing. Another advantage, particularly in the orthopaedic sector, is the optimized accuracy of fit. Protiq uses selective laser sintering (SLS) as a 3D printing process to produce the resistant plastic objects.
The free last configurator enables the creation of individual 3D last models and integrates modeling directly into the ordering process.