

Individual facial reconstruction

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

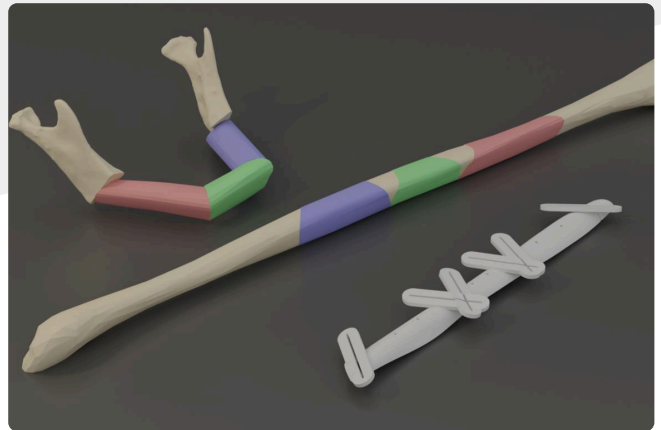
If a large bone defect of the facial skeleton is present as a result of tumor resection, inflammatory diseases (for example, osteomyelitis) or trauma (for example, war injuries or a traffic accident), this requires a complex reconstruction of both bone and soft tissue.

Additive manufacturing, usually known as 3D printing, has been steadily gaining visibility and importance for years. While the technology was initially used mainly for visual models and rapid prototyping, 3D-printed components now perform a wide variety of tasks across a broad range of applications – 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 – for example, medical-grade silicone and quartz glass. What all additive manufacturing processes have in common is that components are built up layer by layer by adding material. Unlike many conventional production technologies – such as turning, milling or EDM – no material is removed; instead, it is added in a targeted manner. This is why additive manufacturing processes are characterized by a high degree of design freedom and flexibility.

Components can be produced directly from the designer's 3D data and individually adapted to the respective application. Combined with fast and cost-effective production of small quantities, this flexibility makes additive manufacturing the method of choice, especially for medical applications.

Components can be tailored to the shape and needs of the patient, which proves advantageous both for the patient and for the treating physicians.



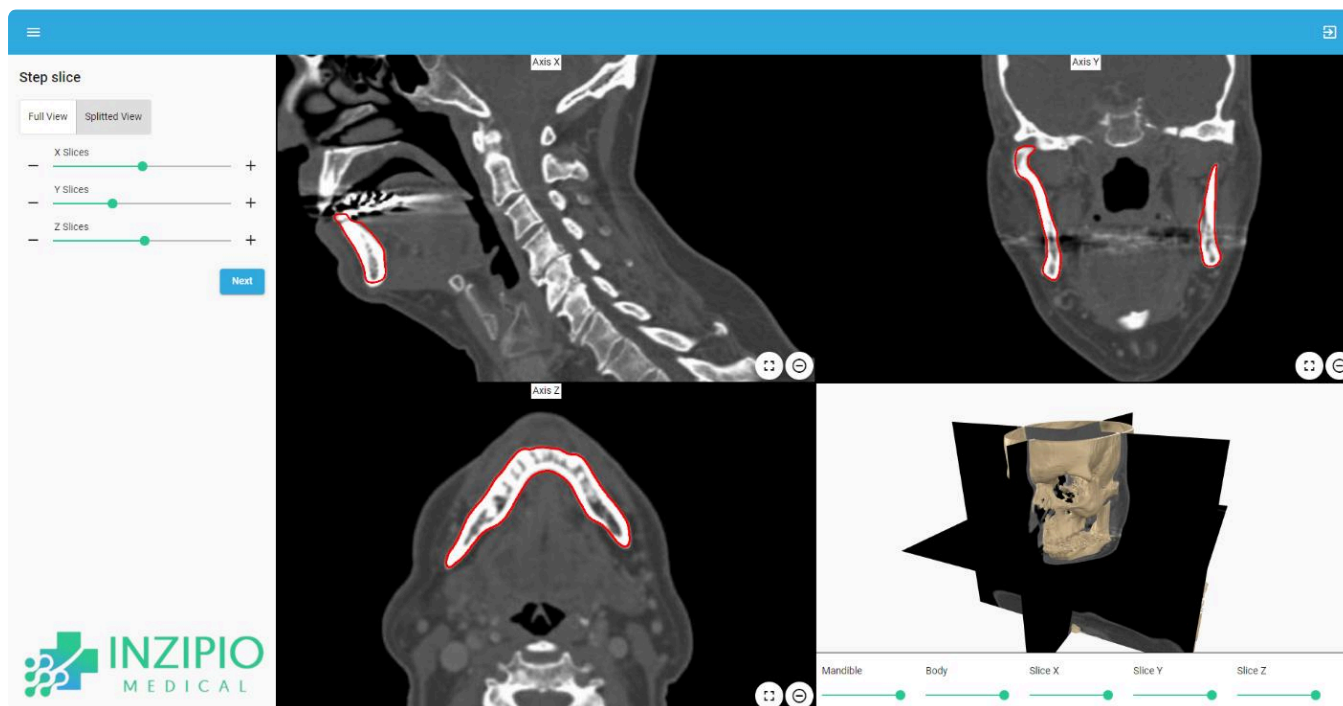
▼ The combination of artificial intelligence and 3D printing enables complex operations to restore the jaw using an autologous microvascular fibula graft. (Source: Inzipio)

Well-known applications on and in the body include custom orthopedic 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 in treatment. This is the context of the collaboration between the medtech startup Inzipio and the additive manufacturing service provider Protiq. Together, the two companies have produced innovative cutting templates, known as 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 wide range of established plastics and metals. At the same time, the company stands out for its active development and qualification of new, innovative materials.

As a spin-off of RWTH Aachen University Hospital, Inzipio is developing medical software that will use artificial intelligence to enable automatic planning of facial reconstruction surgery. Inzipio's solution can generate digital



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

3D data from computed tomography (CT) imaging within a few seconds. Until now, this was a laborious manual process that tied up additional clinical staff or was outsourced to external service providers.

The generated 3D data allow fast, fully digital surgical planning before the actual procedure. The time saved now benefits hospital operations as well as better patient care.

Precise determination of cutting angle and position

Facial surgery in particular benefits from the precision and preparation of upcoming operations. The face not only performs various vital functions – for example, breathing and food intake – but, because it can express emotions, is also closely linked to a person's identity. If a large part of the jawbone and soft tissue has to be removed because of 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 what is known as a microvascular fibula graft. In this procedure, the jawbone is replaced with parts of the patient's own fibula (calf bone). 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 muscle – known

as soft tissue islands – are also harvested from the calf together with the vessel to be connected for supplying the graft. The soft tissue islands are likewise used to reconstruct the facial tissue lost through resection as well as possible.

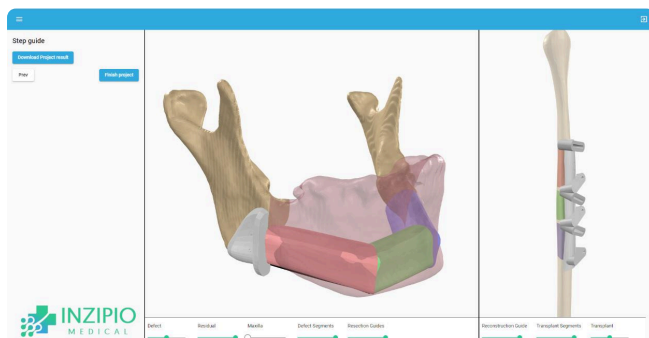
The cutting angle and cutting position required for harvesting the graft are precisely determined in the digital surgical planning. In this way, the actual procedure can be carried out as quickly and efficiently as possible, which increases the chances of success of the operation. Using the fibula as an autologous graft is particularly well suited to this type of procedure. The long tubular bone provides enough material for flexible segmentation of the required bone material and also offers sufficient stability to restore jaw function. Patients are not significantly impaired by the missing fibula, as the tibia can bear the load that occurs when walking on its own.

Additively manufactured cutting guides

To transfer the digital planning precisely to the surgical site, Inzipio can generate patient-specific cutting guides. These are used both for resecting the affected part of the lower jaw and for harvesting the fibula graft. The cutting templates digitally planned by Inzipio can be 3D printed by ProtIQ within a short time before the operation. The components are made of the engineering plastic PA12, are sterilizable and meet all necessary require-



- ▼ 3D representation of a patient with an inflamed lower jaw. Before reconstruction, the affected area is precisely removed using digitally planned and 3D-printed resection templates. (Source: Inzipio)

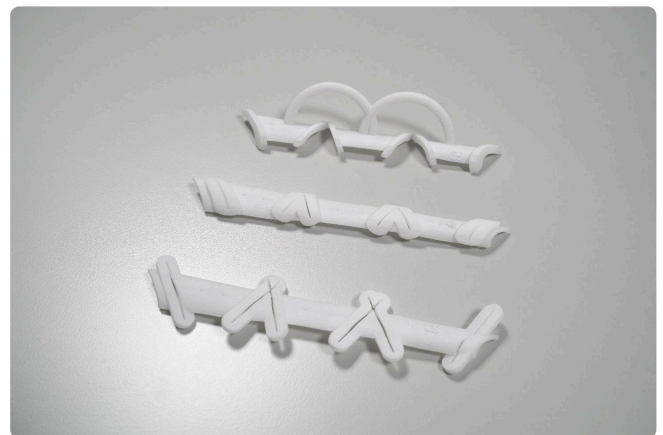


- ▼ Reconstruction of the lower jaw with a segmented microvascular fibula graft. Thanks to the use of digitally planned and 3D-printed cutting guides, surgery time is reduced and precision is increased, thereby achieving a good functional and aesthetic result. (Source: Inzipio)

ments of medical device class 1 for short-term wound contact. These cutting guides indicate the exact position of the cuts to be made, the length of the grafts to be harvested and the required cutting angle so that the shape of the jaw can be reconstructed as planned. A corresponding procedure without these aids – “free-hand,” so to speak – would in principle also be possible, but is limited to smaller defects.

Until the transplanted segments have successfully healed, they are screwed to a titanium plate and thus held in position. This is usually a standard product that is bent into shape using another 3D-printed auxiliary geometry. Alternatively, directly 3D-printed titanium

implants can now also be used, which can already be digitally adapted to the patient.



- ▼ The cutting guides make it possible to transfer the individual digital planning to the surgical site as precisely as possible. For example, the cutting templates allow a U-shaped reconstruction of the lower jaw defect based on planned segment lengths and angles. Cutting guides made of PA12, 3D printed by Protiq. (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 because of the complexity described, they only

become feasible through the use of these novel technologies.

Further information:

www.protiq.com

3D printing in orthopedic shoemaking

Custom-made orthopedic shoes normally take several weeks to produce. A decisive time factor here is the individual production of the lasts used to manufacture the shoes.

This lengthy process can be shortened considerably with additive manufacturing. Especially in the orthopedic field, the optimized fit pays off as an additional

advantage. ProtIQ uses selective laser sintering (SLS) as the 3D printing process for producing the robust plastic objects.

The free last configurator makes it possible to create individual 3D last models and integrates modeling directly into the ordering process.