Virtual planning of extensive jaw reconstructions

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Surgery is still the essential component of curative therapy of malignant neoplasms of the oral cavity. The resection with sufficient safety margins has an immediate impact on the prognosis. Therefore, a partial resection of the jaw is often required. In contrast to the upper jaw defects, which can be treated non-surgically with individual prosthetics and obturators, continuity defects of the lower jaw cause massive restrictions of swallowing, communication and the external appearance. Nowadays, extensive defects are covered in many cases using microsurgical grafts. The extension of the accompanying soft tissue deficit influences the selection of the donor region. The microvascular fibula graft has become the “working horse” in many departments all over the world, when it comes to reconstruction of the mandible, it can be transplanted with or without a skin island and separated in several segments. Advantages of this bone containing flap in particular are a reliable anatomy at the donor site with few variances of the supplying vessels, a large diameter of the pedicle vessels and a comparatively straightforward technique of flap raising. Alternative donor regions are the iliac crest and the scapula.

In our hands, we favour the primary reconstruction of the mandible. That means that the cautery treatment is done followed by intraoperative frozen sections of the soft tissue margins and consecutive reconstruction in the same operative session, which can be ideally performed synchronously in two operation teams. Thus, strain for the patient thereby can be reduced and the adjuvant therapy can begin earlier. However, the exact recovery of the preauricular jaw relation, which is a prerequisite for establishing a satisfying occlusion, is difficult. Even with preoperatively customized osteosynthesis plates, the osseous graft must often be segmented after harvesting to simulate the curve of the mandible.

Nevertheless, the exact creation and positioning of the graft is of great importance for the rehabilitation of the facial symmetry and the masticatory function. Increasing the predictability of the surgical reconstruction outcome can be achieved using a new computer-aided, three-dimensional planning method. This planning enables us to implement precisely the virtually planned jaw resection and the creation of a suitable osseous graft with the help of CAD/CAM templates and an individual osteosynthesis plate. In this article, the technology used by us is described with the aid of an illustrative example in which the resection of the mandible was performed using a CAD/CAM preplanned microsurgical fibula graft.

Process of the planning of complicated facial-surgical interventions

The computer-based virtual planning of complicated surgical interventions in the face contains a planning phase, a production phase and the operation phase.

The planning phase begins with acquiring a defect-related, high-resolution, axial scan of the facial skeleton. This can be performed using a conventional CT or a cone-beam CT (thus minimizing exposure to radiation). When malignant disease is present, the CT of the head and neck, which is necessary in respect of tumour staging, can be used for the planning. In addition, a high-resolution scan of the donor region is required - e.g. the lower leg - which should be combined with an angiography to exclude vessel anomalies. The received data are made anonymous and sent online to the processing company (Materialise (Leuven, Belgium)) via password-protected ftp server. The company then produces a virtual 3D model of both the defect (face) and the transplant donor site (fibula). Now with these data, a web meeting with the engineers of the company and the treating surgeons takes place. In this meeting the resection margins are defined, the segmentation of the bone transplant is discussed and the osteotomy lines are defined. Besides, the positioning of the vascular pedicle and the side of the microsurgical vessel anastomosis in the neck will be defined. After the virtual resection of the jaw, the segmentation of the bone transplant is carried out and the osteotomy lines are defined. As a result, the positioning of the vascular pedicle and the side of the microsurgical vessel anastomosis in the neck will be defined. After the virtual resection of the jaw, the segmentation of the bone transplant is carried out and the osteotomy lines are defined. As a result, the positioning of the vascular pedicle and the side of the microsurgical vessel anastomosis in the neck will be defined.

Now the production of the surgical resection templates for the facial bone and osteotomy templates for the bone transplant takes place. After the production procedure, a 3D stereolithographic model of the postoperative situation (after insertion of the fibula), templates for the osteotomies of the flap and for the tumour resection will be available in the OR. With the help of the 3D model, a 2.0 locking reconstruction plate is manufactured (Synthes, Oberdorf, Switzerland), which is precisely adapted to the postoperative, virtually planned situation.

Intraoperatively, the mandible is surgically exposed so that the resection templates can be positioned to allow performing...
the planned resection. They create a well-defined osteotomy plane. Generally, harvesting of the bone flap (e.g. fibula) is carried out simultaneously through a second team. Harvesting the fibula is performed after exposing the bone in the conventional manner, then fixing the osteotomy templates in the bone with screws. The template as a surgical guide defines the osteotomies which can be performed exactly in the prepared lines. The individual reconstruction plate can be fixed to the fibula with the flap still positioned on the leg which reduces the time of ischemia. After harvesting the microvascular fibula graft, the surgeon positions the transplant into the bony defect of the mandible. The microvascular anastomosis is then performed in the neck vessels. Postoperative 3D cone-beam imaging allows the fusion of pre- and postoperative data and is later used for the planning of the dental implants.

Case presentation
In August 2010, a 30-year-old female patient was admitted to our department with a biopsy-proven chondroblastic osteosarcoma of the left anterior mandible. In our department, the primary radical resection and reconstruction, which is of great importance for the patient. The reconstruction of extensive jaw defects are performed after exposing the bone in the head and neck area as a re-staging diagnostic measure and to determine the current bone situation as a basis for the planning. In the planning session it was defined to use the left fibula and segment it into 5 segments to mimick the mandible arch. The operation was performed in two teams, the osteosynthetic microvascular fibula flap was harvested and osteotomised according to the pre-surgical plan using the osteotomy templates, the pre-bent 2.0 reconstruction plate was fixated to the fibula before ligating the vessels and then the flap was transferred as the neo-mandible to the head and neck region with 52 patients successfully and to now with 52 patients successfully and temporarily dressings awaiting the reconstruction of extensive jaw defects. Plast Reconstr Surg. 1994 Feb;93(2):294-304; discussion 305-6. 7 López-Arias JM, Arias J, Del Castillo JL, Burguería M, Navarro I, Márquez MJ, Chavarría M, Martinez V. The fibula osteomuscutaneous flap for mandible reconstruction: a 15-year experience. J Oral Maxillofac Surg. 2010 Oct;68(10):2377-84.

Conclusion
A good functional rehabilitation and the best possible aesthetic result after reconstruction of extensive jaw defects are of great importance for the patient. The method of virtual planning of jaw resection and reconstruction, which is introduced here, leads reliably to predictable reconstruction results and simplifies the operation process considerably. We have applied this procedure since April 2011 up to now with 52 patients successfully and have established this as a routine workflow in our department.

References

Editorial Note: Full list of references is available from author(s).