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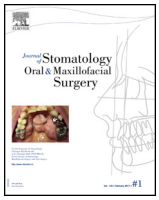

53rd SFSCMFCO Congress

New aspects in free flap surgery: Mini-perforator flaps and extracorporeal flap perfusion☆

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ABSTRACT

Background: The scope of microvascular tissue transfer in the Head and Neck reaches from coverage of simple soft tissue defects to complex 3-D reconstructions using multiple or chimeric flaps. This paper summarises the presentation given at the Congress of the French Society of Oral and Maxillofacial Surgery in Marseille 2017. It was the aim of our work to add further elements to this wide spectrum of reconstructive possibilities.
Methods: For patients with small intraoral soft tissue defects in whom the use of a radial forearm flap would not be justified because of its donor site morbidity, but who nevertheless would take a benefit from a small free flap, we used mini-perforator flaps from the lower leg. These flaps were raised with negligible morbidity. Moreover, for patients necessarily needing a free flap, but having vessel depleted, irradiated necks, we have developed a first idea of extracorporeal flap perfusion to make microvascular anastomoses unnecessary.
Results: Using donor sites from the lower leg, mini-soleus and medial sural perforator flaps were raised to cover defects of 2 × 3 to 2 × 4 cm at the anterior floor of the mouth or lateral tongue. The success rate was 91%, and despite their small size, the flaps helped to maintain the mobility of the tongue. The donor site morbidity was minimal. After extensive experimental work on small animals and human tissue, four flaps could successfully be transferred so far by means of extracorporeal perfusion. In these patients, autonomisation took place between 5 and 12 days.
Conclusions: Although microvascular tissue transfer already allows for reconstruction in almost any possible defect constellation, mini-perforator flaps and machine-perfused transplants seem to represent new aspects of free flap surgery, being useful extensions of the reconstructive surgeon's armament.

1. Introduction

After the first free tissue transfer by Seidenberg, who in 1958 replaced the carcinomatous part of a human esophagus with a tubed segment of the jejunum by means of microvascular anastomoses [1] and the first free dermis–fat flap pedicled at the superficial epigastric artery and vein for covering of a skin defect at the face by Antia and Buch in 1971 [2], microvascular tissue transfer has made an enormous progress. Today, with the numerous proven flaps developed so far, no reconstructive problem seems to remain any more. Whereas the radial forearm flap in Maxillofacial surgery still is the workhorse flap for intraoral lining [3,4], the fibula became the first option for osseous reconstructions particularly of the mandible [5]. Even the most complex defects needing extensive amounts of composite tissues can be mastered by chain-linked or chimeric flaps [6,7], which simultaneously are harvested from one or more donor sites using a multiple team approach. On the other hand, harvesting a free flap is always associated with the creation of a certain donor site morbidity. Therefore, the indication for microvascular tissue transfer is only made if there is a considerable defect, which for technical or functional reasons cannot be closed directly. Thus, smaller defects normally are no indication for a free flap. Nevertheless, especially in mobile parts of the oral cavity, primary closure even of small defects can lead to functional limitations. In particular the tongue can be tethered by scar tissue after closing the floor of the mouth defects directly. Because skin grafts only take poor in the oral cavity, small free flaps, raised with only a minimal morbidity at the donor site, would be a perfect solution if the patient wishes to have an optimal functional outcome. For this purpose, we have used mini-perforator flaps from the lower leg.

We also were looking for a solution in situations, were a free flap is urgently needed but impossible to perform because of

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missing or for any reason unsuitable recipient vessels. Although in these patients, reconstructions still might be possible by using pedicled flaps or by anastomosing free flaps via vein grafts or loops [8–12], it was the aim of our research to find a possibility for flap perfusion completely independent from the patients vascular system. Based on the observation that after an inadvertent early disruption of the pedicle, flaps can survive due to autonomisation that has occurred within the first 6–14 days [13,14], extracorporeal perfusion was supposed to be necessary only for short time. Extensive experimental work has been done before trying the first extracorporeal perfusion in a patient.

2. Materials and methods

Beginning in 2001, patients with squamous cell carcinomas of the floor of the mouth or tongue not larger than 2 cm in diameter were chosen as candidates for mini-perforator flaps. In these patients, tumour resection has created a maximal defect of 3 × 4 cm. In all patients, elective neck dissection was indicated. The patients were fully informed about the possibility to close the defect directly or to use either a radial forearm flap or a mini-perforator flap from the lower leg. If the patients decided to have a less conspicuous donor site than the forearm, the soleus or medial sural perforator flap was offered. In tongue defects, needing a little bit more bulk, the medial sural flap was favoured, whereas the soleus perforator flap was the first choice for small defects of the floor of the mouth. Because only a small piece of skin was needed, exact preoperative localisation of the perforator was crucial to outline the skin incision precisely and close to the perforator. To this end, a handheld Doppler was used for mapping the most suitable vessel, the day before surgery, with the patient standing upright. The general technique for flap harvesting was a retrograde dissection of the perforator, which first was exposed below the deep fascia. After having identified the perforator, it was traced towards its source vessel by intramuscular dissection. Soleus perforator flaps were directly anastomosed to their perforating vessels, which were ligated at their exit from the peroneal vessels. The medial sural vessels were dissected in such a length that tension-free anastomoses were possible. Anastomoses were performed either to the facial or thyroid superior vessels, and the donor defect at the lower leg was closed primarily in all cases.

As already described [15], three patients with mandibular defects and missing or unsuitable neck vessels have been reconstructed before using an extracorporeal perfusion device, but this device needed permanent supervision for up to 12 days. Another disadvantage of this system was the cumulative blood loss, because no re-infusion of the perfusate was carried out. Therefore, an extracorporeal perfusion system that was established for lung and cardiac support was modified and tested to perfuse free flaps. First, flaps from fresh human bodies were examined (Ethical committee Klinikum rechts der Isar 1284/17). In a closed circulation using oxygenated blood at body temperature, radial forearm and anterolateral thigh flaps were perfused with different pressures and flow rates. Capillary blood flow within the flaps was continuously measured with varying perfusion parameters. After successful testing, the system was applied in one patient with an irradiated vessel in a depleted neck to close a deep skin defect that has resulted from raising a deltopectoral flap at the shoulder (Ethical committee Klinikum rechts der Isar 5836/16, ClinicalTrials.gov NCT02449525).

3. Results

Out of 131 perforator flaps from the lower leg, which we have done since 2002, 38 were mini-flaps. Of these, 31 were soleus perforator flaps, and 7 were medial sural perforator flaps. Defects were located at the lateral tongue [12], the floor of the mouth [17] or in both areas. None of the defects were larger than 3 × 4 cm, most of them measured only 3 × 3 cm. There were 27 men and 11 women with an age of 60 years on average. Flap raising could be performed without particular difficulties, but in 4 patients (3 medial sural and 1 soleus perforator flap), preoperative mappings deviated more than 2.5 cm from the intraoperative position of the perforators. In 2 medial sural perforator flaps, another perforating vessel was chosen instead, leading to an extended scar at the donor site. There were three flap losses (2 soleus and 1 medial sural perforator flap). Whereas flap transfer caused no problems in the medial sural flap because of its long and large diameter pedicle, soleus perforator flaps had an average pedicle length of 5 cm only and were more difficult to anastomose (Fig. 1). In these flaps it was crucial to preserve the recipient vessels (facial or thyroid superior artery) as long as possible during neck dissection. Moreover, the diameter of the perforating artery could be even less than 1 mm, so that a careful dilatation was necessary for proper suturing. In two soleus flaps and one medial sural flap, vascular spasm of the artery occurred, probably caused by intramuscular dissection. This complication could be overcome with topical Papaverin application. At the donor leg, there were no functional limitations, and all but one patient were satisfied with the appearance of the scar. Only a slight contour deficit resulted from flap raising in medial sural flaps. The small flaps were very well suited to maintain the mobility of the tongue and for normal speech and swallowing (Fig. 2). Therefore, all patients were very satisfied with the functional results obtained with the mini-perforator flaps.

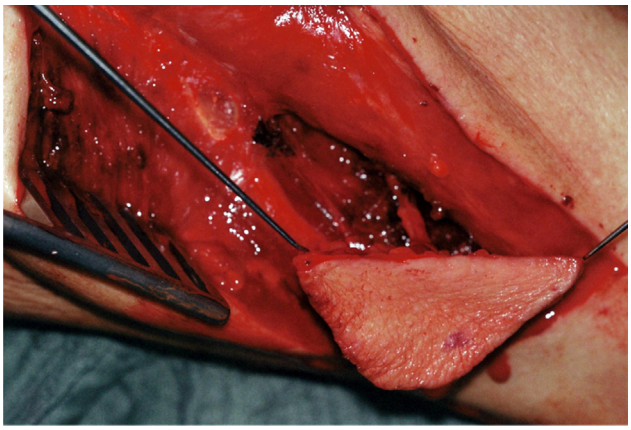

Fig. 1. Raised mini-soleus perforator flap.

Also the second aim to perfuse flaps with an extracorporeal device could be pursued any further. Anterolateral thigh and radial

Fig. 2. Result of reconstruction at the lateral tongue at 6 months.

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forearm flaps, taken from fresh bodies, were successfully perfused with diluted whole blood, and full circulation was obtained with significant bleeding from the flap margins. By re-infusing the leaking blood into the system, values of intracapillary flow and tissue oxygenation were comparable to measurements using the O2C-monitoring device in patients [16]. These measurements could be sustained for at least 180 min. Varying the perfusion pressure and flow rates generated by the system, the circulation within the flap responded accordingly, but due to the fact that the flaps — although taken from fresh, cold preserved cadavers — were not (fully) vital any more, no oxygen consumption was expected to occur within the flaps. Nevertheless, the suitability of our experimental setting to keep up a flap circulation has been proved, and it was possible to produce hemodynamic parameters very similar to the clinical situation. Another important aim of our pre-clinical evaluation was to develop a minimal invasive solution for extracorporeal perfusion, not affecting the patient's circulation and mobility. Our experimental setup has shown that our device works independently from the patients vascular system. Therefore it offers the possibility to connect or disconnect the flap from the artificial circulation.

After having done three extracorporeal perfusions of composite flaps by using an early version of the device as reported previously [15], the system described in this paper first was used in a patient with an irradiated, previously operated neck and vessels unsuitable for straightforward free flap transfer. Two free flaps have already been lost in this patient, and he suffered from a wide perforating defect to the chin and submandibular region. Following the concept of providing a reconstruction as safe as possible, the intraoral and neck defect was closed by a combined deltopectoral and pectoralis major flap, which worked well. Because all tissue from the deltopectoral flap was needed to replace the neck skin, no repositioning of the tubed flap's pedicle was possible, resulting in a deep and wide donor defect at the shoulder. In order to restore volume and flexibility of the skin, we decided to close the defect at the shoulder with a thinned anterolateral thigh flap, perfused by the extracorporeal system. After having identified the main perforator at its expected position, the flap could quickly be raised above the deep fascia, leaving all muscle and nerve structures untouched. To speed up autonomisation, the flap was thinned, but a cuff of fatty tissue was left around the perforator. The perforator was traced to the descending branch, and a short segment of the source vessel was included for easier cannulation of the flap. A cannula was inserted into the artery and vein, and the flap was connected to the system. Complete perfusion of the flap was obtained, and capillary refill and fresh bleeding from the margins were visible. Perfusion using diluted blood was maintained over four days, but the flap was regularly disconnected from the system to allow the patient to leave the bed and walk around freely. During this time, the flap was covered by a firm gauze to prevent dislocation, which would have impeded quick neovascularisation (Fig. 3). The procedure was tolerated by the patient very well, and no complication as hematoma, infection, or bleeding occurred. The perfusion solution was changed every 24 hours without noteworthy blood loss. On the 5th day, perfusion was terminated, and the flap was left to further spontaneous neovascularisation. At this time, the flap ad a bluish appearance, but there was no loss of epithelium. However, after another 2–4 days, necrosis developed at the perforator's entrance point into the flap where a certain amount of fatty tissue was left to protect the pedicle (Fig. 4). Here, the bulky part of the flap was not yet fully autonomised, and about 3 × 4 cm skin out of 14 × 10 cm flap tissue was lost. After partial granulation, this area was directly closed later under local anaesthesia. Except from this, the flap healed without further complication.

Fig. 3. Patient during extracorporeal perfusion of a thinned anterolateral thigh flap at the right shoulder.

Fig. 4. Anterolateral thigh flap after transfer using extracorporeal perfusion with partial necrosis.

4. Discussion

Although the level of free tissue transfer is already excellent, leaving almost no reconstructive problem unsolved, in clinical practise, some situations still remain needing ideas for further improvement. In our paper, two examples of such situations are given. First it could be shown that free flap transfer can be meaningful even in situations, which would not necessarily need a reconstruction. As our results have shown, mini-perforator flaps harvested from a well accessible but during daily life, almost invisible donor site like the lower leg, perform very well for closure of small defects in mobile parts of the oral cavity. Other than direct wound closure, these mini-flaps provide full mobility of the tongue. The donor site morbidity is almost negligible and the procedure can be carried out in two teams, reducing the time needed for reconstruction. Therefore, we consider mini-perforator flaps to be justified in small tumours, if the patients wish to have the best possible result.

The second problem, which needs further scientific and clinical input is the patient with inadequate or completely missing recipient vessels. Although our experience with the extracorporeal perfusion procedure still is very limited, the results obtained so far can serve as a proof of principle. Nevertheless, many questions

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concerning optimal flow, perfusion times and — intervals, composition of the perfusion solution, reliability of autonomisation and optimal flap design still need to be answered. Whereas 10–12 days of perfusion were needed for composite flaps, only 5 days were sufficient for a thinned anterolateral thigh flap. The differences of methods and devices we have used make clear that we still are far away from claiming that extracorporeal perfusion is predictable and reliable. Therefore, it is the aim of our future research to provide a standard protocol for this procedure, which might add further possibilities for reconstructive surgeons.

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Disclosure of interest

The author declares that he has no competing interest.

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