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Results of monitoring fasciocutaneous, myocutaneous, osteocutaneous and perforator flaps: 4-year experience with 166 cases

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Abstract. Four free-flap types were compared regarding perioperative blood perfusion parameters and to define critical values for success. 166 cases were investigated: radial forearm flap (fasciocutaneous, n = 89); fibula flap (osteocutaneous, n = 32); ALT flap (myocutaneous, n = 25); soleus perforator flap (n = 20). All flaps were monitored with simultaneous laser-Doppler flowmetry and tissue spectrophotometry intra- and postoperatively up to 14 days. In 24 (15%) of 166 cases perfusion irregularity occurred. Operative exploration was performed in 12 cases (9 successful). 11 flaps (5 radial forearm, 3 fibula, 2 ALT, 1 perforator) were lost due to vascular compromise, which led to an overall success rate of 93%. Rapid increase in haemoglobin concentration of $> 30\%$ identified venous congestion. Abrupt decline of blood flow and haemoglobin oxygenation indicated arterial occlusion. For radial forearm flaps haemoglobin oxygenation of 15% and a deep flow of 20 AU were identified as minimum values for flap viability. For fibula, ALT, and perforator flaps haemoglobin oxygenation of 10% and a deep flow of 15 AU were determined as the minimum values. This non-invasive technique was an accurate method for evaluating viability of free-flaps.

Keywords: plastic reconstructive surgery; free-flap monitoring; microsurgery; tissue oxygenation; tissue perfusion; perforator flaps.

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Flap failure can be avoided through early recognition of compromised flap perfusion. Owing to the limited ischaemia time of the tissue, immediate surgical intervention to re-establish vascular patency is the key to successful salvage rates of 70% and more[2,6,14,18,27,35].

The authors report the first monitoring device that allows non-invasive simultaneous measuring of quantitative blood flow and haemoglobin oxygenation[10,11,12,15,21]. It also identifies arterial occlusion and venous congestion, which is essential for increasing the success rate in free-flap transfer[8,16,19]. Often venous congestion is recognized too late[1,9], which makes surgical intervention futile.

The authors' 4-year experience with the O2C (Oxygen-to-see, LEA-Medizintechnik GmbH, Gießen, Germany) monitoring device in different types of free-flaps shows that it is an excellent method for supporting clinical observation and making it objective. It can be applied to all types of free tissue transfer, provided that a cutaneous part is included.

The aim of this prospective study was to investigate the reliability of non-invasive simultaneous application of laser-Doppler flowmetry and tissue spectrophotometry in fasciocutaneous, osteocutaneous, myocutaneous and perforator flaps and recommend critical values for each flap type.

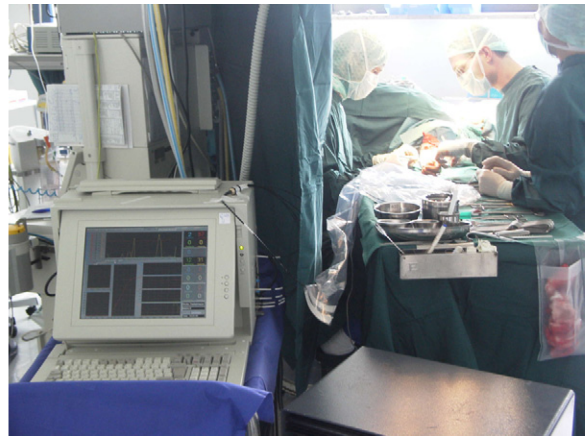

Fig. 1. O2C in the operating room, well integrated while a flap is being raised, presenting microvascular parameters online.

Patients and methods

Between 2003 and 2006, defined intraoperative and postoperative flap monitoring was carried out in 166 different free-flaps in 162 patients (4 patients received 2 transplants). Fasciocutaneous radial forearm flaps (n = 89), osteocutaneous fibula flaps (n = 32), myocutaneous ALT flaps (n = 25), and soleus perforator flaps from the lateral lower leg (n = 20) were investigated. Pure fascial, myoosseous and all types of buried flaps were excluded. The patient population consisted of 57 women and 105 men with a mean age of 56.4 years (range: 12–82 years). Of these 162 patients, 79% were smokers at the time of operation or had smoked previously.

The tissue oxygen analysis system O2C (Oxygen-to-see, LEA-Medizintechnik GmbH, Gießen, Germany) was used, which is described in earlier publications[10,11,12]. This diagnostic device was developed to facilitate the observation of vitality in organs and transplants. In contrast to other non-invasive assessment probes, it permits simultaneous non-invasive measurement of blood flow (AU, arbitrary units), flow velocity (AU), haemoglobin concentration (Hb_{conc} in AU), and haemoglobin oxygenation (SO_2 in %). The monitor provides online measurement of the microvascular parameters (Fig. 1) and is connected to the probe in a sterile cover sheath.

Operative technique

Preoperatively, Allen‘s manoeuvre helps test blood perfusion of the hand through the arteria ulnaris. The fasciocutaneous forearm flap was raised with the help of tourniquet ischaemia in 61 patients and without it in 28 patients. In all cases, the flap was pedicled at the radial artery. For venous drainage, one of the comitant radial veins (n = 52) or the cephalic vein (n = 20) was anastomosed. In 17 flaps, blood drainage was low after finishing the first anastomosis, so two venous anastomoses were carried out using two comitant radial veins (n = 9) or one comitant vein in combination with the cephalic vein (n = 8).

Evaluation of lower leg perfusion was carried out routinely by magnetic resonance angiography before microsurgical fibula transfer.

In cases of ALT and perforator flaps from the lateral lower leg, preoperative audible Doppler examination was performed to locate perforator vessels.

For arterial anastomosis, the arteria thyroidea superior was chosen in almost 50% of all cases (n = 81), followed by the arteria facialis (n = 63). Other less frequently used vessels were arteria carotis externa (n = 12), arteria lingualis (n = 7) and arteria temporalis superficialis (n = 3).

For venous drainage, the vena jugularis externa (n = 55), the vena retromandibularis (n = 44), the vena facialis (n = 24) or vena thyroidea superior (n = 21) were used most often. Vena jugularis interna, vena jugularis anterior and vena transversa colli were used rarely. For venous drainage of perforator flaps small diameter vessels, such as vena comitans nervi hypoglossi (n = 9) or vena lingualis (n = 6) were mainly chosen.

The operations were carried out by 8 different surgeons. Average operating time was 8.5 h and flap ischaemia time varied from 78 to 139 min (average 104 min). During postoperative management 5000 I.E. of heparin were given three times daily as an intracutaneous injection.

Monitoring

All flaps underwent intraoperative and postoperative monitoring of tissue oxygenation and microvascular perfusion. All measurements were carried out using O2C. This device permits simultaneous non-invasive and depth-selective measurement of blood flow, flow velocity, haemoglobin concentration and oxygenation at two tissue depths (2 and 8 mm). According to a defined format, measurements were started intraoperatively (after flap raising, after flap removal, after anastomosis and after reconstruction) and continued up to 14 days with measurements taking place on postoperative days 1, 2, 3, 7, 10 and 14.

Measuring blood flow with the laser-Doppler

Blood flow was measured with an O2C laser-Doppler flowmetry unit. Tissue is illuminated with coherent laser light of 820 nm wavelength and 30 mW power through a fibre-optic cable. Backscattered light is collected by the same probe and frequency shifted light extracted by a heterodyne light beating technique. The power spectral density of shifted light is a linear function of the average velocity of moving cells within the tissue. Probe geometry allows detection of blood flow and flow velocity up to 8 mm depth. Recording speed was 40 measurements per second, which allowed for pulsed synchronous measurements.

Measurement of tissue oxygen saturation with tissue spectrophotometry

Microcirculatory intracapillary oxygen saturation was measured with the O2C-tissue spectrophotometer by backscattering spectrophotometry. Visible white light was beamed into the tissue by the same probe that was used for Doppler measurements. The backscattered light spectrum was measured over the whole range of 500–630 nm. The light-illuminating and