Evaluation of Foot Perfusion After Fibula Flap Surgery

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Abstract: Fibula flap is widely used in reconstruction work, whereas the low extremity blood supply alteration was unclear. This study would observe the blood oxygen saturation change of foot after harvesting fibula flap. The regional tissue oxygen saturation (rSO_2) of the lateral side and inner side of feet was measured using near-infrared spectroscopy oxygen monitoring system (NIRS) before operation and in postoperative day 1 to 7, and the foot of the control side was measured as control. The rSO_2 of the donor side foot decreased less than 5% ($P < 0.05$) in the first 8 hours after operation and recovered to the level of the control side later. NIRS is ideal for measuring rSO_2 of donor side foot after fibula flap. The rSO_2 of the donor side foot decreased less than 5% after fibula flap harvesting.

Key Words: Near-infrared spectroscopy (NIRS), regional tissue oxygen saturation (rSO_2), fibula flap, donor site

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The autogenous, vascularized, free fibula flap is a "workhorse" flap used for the reconstruction of long osseous defects, especially oral maxillofacial defects. In comparison with other osteocutaneous flaps, the fibula flap offers many advantages and is associated with low subjective morbidity.[1–3] Variant blood supply to the foot has been reported in 5.6% of cases, and atherosclerotic disease of the lower extremities is often found in elderly individuals.[4] The most serious potential donor-site complication after fibula flap transfer is foot ischemia secondary to the sacrifice of the peroneal artery.[5,6] After years of practice and study, the necessity for preoperative angiography of the lower extremity before the harvesting of free fibula flaps remains controversial. Until now, the short-term effects of fibula flap harvesting on the blood supply of the foot was unclear. In this study, we monitored blood oxygen saturation of the foot after fibula flap surgery by using a near-infrared spectroscopy (NIRS) monitoring system to detect postoperative changes in the blood supply of the lower extremity.

PATIENTS AND METHODS

This study included 47 patients (21 men, 26 women; median age, 44 yr; range, 17–70 yr) who underwent autogenous, vascularized, free fibula flap transplantation for mandibular reconstruction because of a tumor. Before the operation, arterial deficiency in the leg to be operated on was ruled out by using Doppler ultrasonography to localize the dorsalis pedis artery in the foot and the peroneal and posterior tibial arteries at the level of the ankle. The exclusion criteria were a history of trauma or developmental anomaly of the lower leg.

In all 47 patients, the regional tissue oxygen saturation (rSO_2) of the lateral and medial aspects of both feet was measured using NIRS before operation and on postoperative days 1 to 7 (Fig. 1). The measurements were performed once every 4 hours during the first 24 hours after the operation and twice a day during the following 6 days. The rSO_2 values of the contralateral, healthy foot were used as controls.

The NIRS instruments were developed by the Tsinghua University Department of Biomedical Engineering. Probes with a double light source and a double near-infrared PIN (position indicator) detectors were used. Light-emitting diodes with dual wavelengths of 730 nm and 850 nm were placed 30 mm and 40 mm from the receiver, respectively. NIRS probes can be placed directly on the skin surface and can penetrate tissue up to a depth of 20 to 30 mm.[7]

Statistical Methods

Data are presented as the mean and standard deviation. Differences among groups were analyzed by the paired *t* test. *P* less than 0.05 was considered statistically significant.

RESULTS

Varying degrees of edema were observed on the dorsum of the donor foot in most patients, but circulatory disturbances of the lower limb did not occur. The oxygen saturation of the medial and lateral aspects of the donor feet was greater than 50% on the day before and 1 to 7 days after the surgery. Changes in oxygen saturation showed an initial increasing and a subsequent decreasing trend.

Compared to the control values, the rSO_2 of the lateral aspect of the donor feet was decreased by 1% to 3% at 0, 4, and 8 hours after the operation ($P < 0.01$); this decrease disappeared at 12 hours after the operation. At 120 hours, the rSO_2 of the lateral side was higher in the donor feet than in the control feet ($P < 0.05$), but no difference was observed after this time (Fig. 2A).

In the case of the rSO_2 of the medial side, significant differences between the donor and control feet were only found at

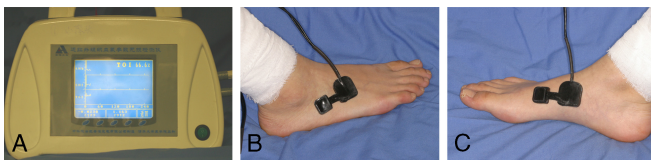

FIGURE 1. A, Near-infrared spectroscope (NIRS) showing 66% tissue oxygen saturation on the lateral aspect of the foot after fibula flap surgery. B, An NIRS probe on the lateral (B) and medial (C) aspects of the donor foot.

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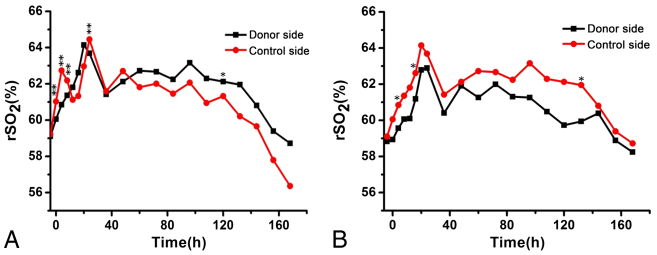

FIGURE 2. Regional tissue oxygen saturation (rSO_2) of the lateral (A) and medial (B) aspects of the donor feet before and after the harvesting of a fibula flap. The rSO_2 of the contralateral foot was taken as the control. *$P < 0.05$ compared with control side, ** $P < 0.01$ compared with control side.

4 hours after the operation ($P < 0.05$); at this time, the rSO_2 of the donor feet was 4.9% lower than that of the control feet (Fig. 2B).

DISCUSSION

The collateral circulation of the foot is complex and variable, and presents a great challenge to the surgeon attempting to avoid postoperative circulatory disturbances of the foot. The foot derives its blood supply from branches of the posterior and anterior tibial arteries. The peroneal artery, a collateral branch of the posterior tibial artery, enters the sole and gives rise to the lateral plantar artery. The lateral plantar artery unites with the terminal end of the dorsalis pedis artery to form the deep plantar arch that supplies the toes and lateral foot. The destruction of any one of these vessels will not lead to ischemia of the foot because of the complex collateral circulation.[8]

The peroneal artery is not usually the main route of blood supply to the foot and lower part of the leg; rather, the anterior and posterior tibial arteries are the main sources of blood supply.[9] However, variations in this arterial anatomy occasionally occur. Yoshimura et al have reported missing anterior or posterior tibial arteries.[10] Disa and Cordeiro evaluated 100 consecutive patients as potential candidates for free fibula flap surgery; they concluded that routine preoperative arteriography was unnecessary and should be reserved for patients with abnormal vasculature.[5] In our experience, preoperative detection of the peroneal and posterior tibial arteries in the ankle and dorsalis pedis artery in the foot on Doppler ultrasonography should be performed to ensure the existence of the 3 arteries, and no ischemia of the foot after fibula flap surgery was found.

Tissue oxygenation in the distal part of the donor limb can increase significantly because of vascular changes, which are possibly a result of endothelial damage at the operative site.[11,12] The trends observed in the changes in oxygen saturation of the donor foot after fibula flap reconstruction were similar to those observed after trauma; oxygen saturation initially increased and subsequently decreased to the control level within 7 days after the operation.

Techniques of blood flow measurements such as ultrasonography, hydrogen clearance and laser Doppler, pulse oximetry, and plethysmography can be used to assess limb perfusion,[13,14] although they are of limited use in measuring the perfusion of a block of tissue. NIRS is a relatively new, noninvasive technique that allows continuous and immediate monitoring of changes in tissue oxygen saturation at various depths. During its early stages of development, NIRS was used in reconstructive surgical experiments to observe the perfusion of transplanted flaps.[7] In this study, we measured tissue oxygen saturation at a depth of 2 to 3 cm. The rSO_2 at this depth clearly reflects the local block perfusion of the foot.

We found that the rSO_2 of the lateral aspects of the donor feet decreased by less than 5% of the corresponding value for the control feet within several hours after the operation and increased slightly thereafter when compared to the preoperative value. The differences in rSO_2 between the donor and control feet lasted for only 8 postoperative hours in the case of the lateral side and for only 4 postoperative hours in the case of the medial side. Thus, the blood supply of the donor foot was minimally affected by the sacrificing of the peroneal artery during the fibula flap operation; moreover, the observed changes in blood supply were mainly restricted to the lateral aspect of the donor foot. Collateral circulation from the posterior and anterior tibial arteries was sufficient to meet the perfusion requirements of the foot.

CONCLUSIONS

NIRS is ideal for measuring rSO_2 of the donor foot after fibula flap surgery. If the peroneal artery, posterior tibial arteries, and the dorsalis pedis artery can be demonstrated in the donor foot on Doppler ultrasonography before the operation, sacrificing the peroneal artery will not lead to ischemia of the foot. In this scenario, the rSO_2 of the donor site decreased by less than 5% after fibula flap harvesting.

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