Vascularisation of random pattern flaps and skin grafts: in vivo prospective study by laser speckle contrast analysis

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Laser Speckle Contrast Imaging (LSCI) is a non-invasive, real time and in vivo technique used for the imaging of blood flow, allowing rapid, contactless, accurate and reproducible measurements over large surface areas, which makes it a valuable and promising tool for a skin flaps and skin grafts microcirculation study.

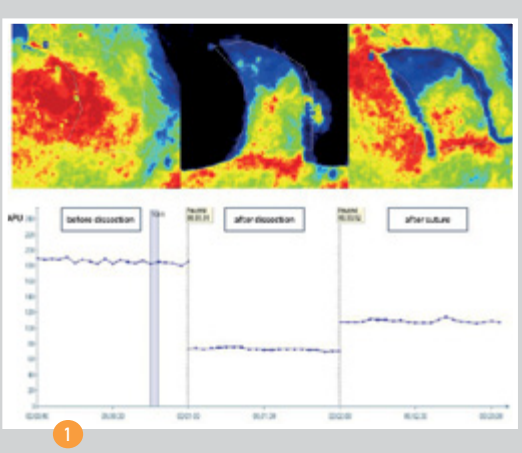
Random pattern skin flaps lack a defined vascular pedicle and depend on the vascular flow in the dermal and subdermal plexuses. This flow decreases according to the distance to the nutritive perforating vessels near the flap base and there is a critical perfusion pressure under which the survival of the flap is compromised. This critical perfusion pressure cannot be estimated and the flaps are planned empirically. Also, skin grafts lack their own vascularisation, but the creation of capillary anastomoses and the centripetal development of new vessels seems to allow the restoration of a vascular flow from 24-48 hours of healing time.

This project was selected for funding by EADV's Project Proposal Review Committee in 2015 and is based on a prospective study designed to assess the dynamics of vascular flow along the evolution of skin flaps and grafts healing. The main scope of the proposed study is:

- to compare the microcirculatory functional response at different healing times and between different regions of skin flaps and skin grafts
- to develop a mathematical model capable of estimating critical perfusion pressure and optimise the design of skin flaps.

The goals of the study are to test the following hypotheses:

- the blood flow in random skin flaps varies according to the distance from the base of the flap and during the healing time
- the blood flow in skin grafts varies according to the zone of the graft (periphery versus centre)



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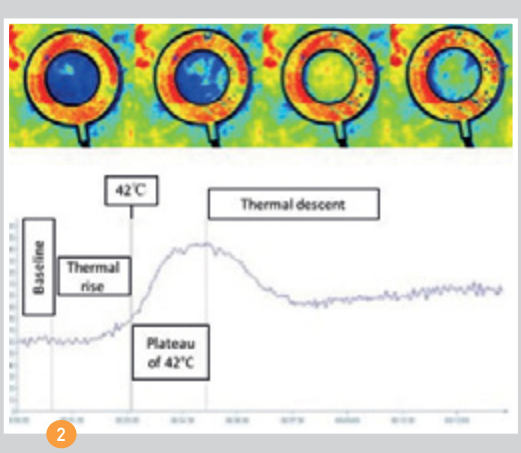

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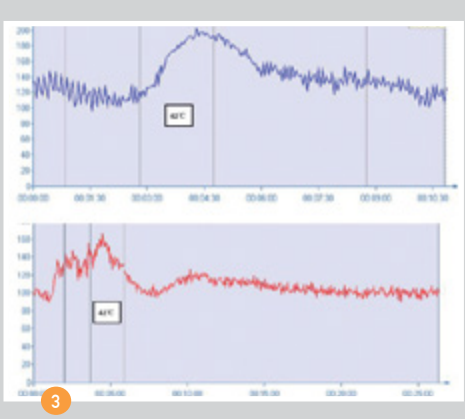

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- the vascular dynamic response to provocation tests can be different in flaps or grafts when compared to normal skin.

Flaps and skin grafts performed in patients with defects resulting from surgical removal of skin lesions are being evaluated under LSCI. Each flap or graft is evaluated in the immediate postoperative period, at days 7 and 28 for skin flaps, and at days 1-7, 14, 21 and 28 for skin grafts. Demographic and clinical variables are also collected for statistical analysis.

A pilot clinical study has already been done, with LCSI measurements performed on three different patients submitted to random skin flaps: an advancement, a rotation, and a transposition flap. Measurements of skin blood flow were obtained immediately before and after the flaps were dissected, and after the flaps were sutured. The results were consistent with our expectations: perfusion pressure measured in the flaps decreased from the baseline (before flap undermining) up to flap suture, and we were able to prove that variation of perfusion pressure along the flap is dependent on the length to width ratio, being an exponential decreasing function (Figure 1). On the 7th and 28th postoperative days, skin flap microcirculation was stimulated, with local heating, in order to study its reactivity, on the base and tip of the flap. Microcirculation reactivity was higher at the control skin than on the flap, although it could be already noticed (Figures 2 and 3).

Regarding the study of skin grafts with LSCI, we were surprised to verify that perfusion did not begin at the periphery of the graft but at its centre, beginning to become apparent at day 5 and evolving favourably thereafter, in the case of a full-thickness skin graft on the dorsal hand (Figures 4 and 5). More studies are needed to be able to assess skin graft microcirculation dynamics during healing time.

The project is innovative because the main studies on this issue were performed with laser Doppler. As shown in comparative studies the two techniques are not overlapping - laser speckle being the one that involves fewer variation measurements between different zones of an area of interest. This poor correlation between the techniques and the lower reproducibility of laser Doppler are related with two different factors. On the one hand, the highest penetration of laser Doppler adds data for deeper and larger vessels. On the other hand, the image obtained by laser Doppler is captured by scanning and is prone to register variations in the microcirculatory state susceptible to occur in the time interval in which the measurement takes place.

The results obtained with our project may benefit EADV members, namely those who perform reconstructive surgery, and may contribute to a better knowledge about skin anatomy and flap/graft physiology. Simultaneously, the benefits for the patients are also visible. The impact of the project can be enlarged upon due to its originality and feasibility.

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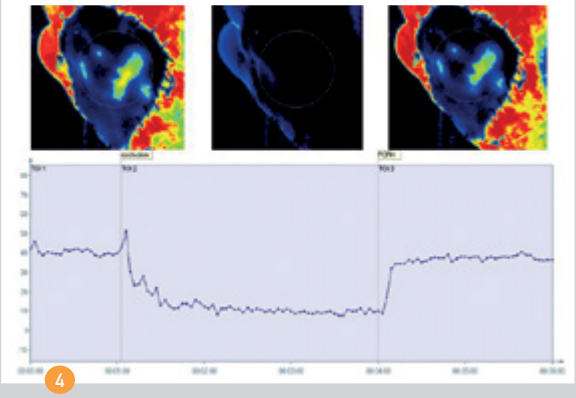
***Figure 1**: Day of surgery. Random pattern rotation flap before dissection, after dissection and after suture, under LSCI images and graphs, showing differences in perfusion (semi-quantitative colour scale, where black means absence of perfusion, blue means very low perfusion, green means low perfusion, yellow means moderate perfusion, orange means high perfusion and red means very high perfusion)*

***Figure 2**: Day 7, base of the flap. Random pattern rotation flap image perfusion and graph at baseline, during thermal rise to 42°C, at 42°C plateau, and during thermal descent*

***Figure 3**: Control skin (blue) and flap (red) graphs at microcirculation heating test, day 7*

***Figure 4**: Full-thickness skin graft under LSCI images on dorsal hand, from day 1 to 28 after surgery*

***Figure 5**: Full-thickness skin graft under LSCI images and graphs: at baseline, under occlusion, and during post-occlusion reactive hyperemia*



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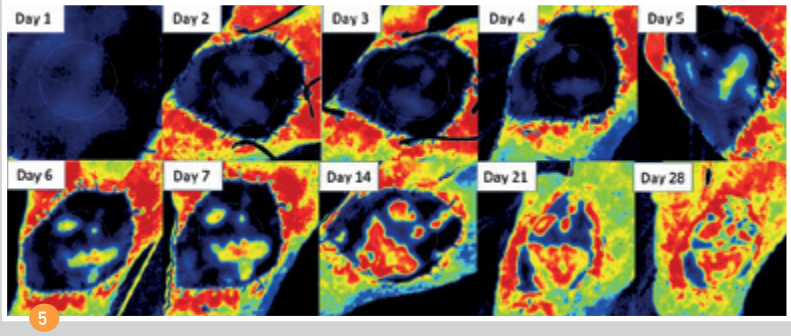

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