Seeing the Unseen:

Novel perfusion monitoring in oculoplastic surgery

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On April 29, 2022, Johanna V. Berggren defended her thesis "Perfusion Monitoring in Oculoplastic Reconstructive Surgery" at the Faculty of Medicine, Lund University, Sweden. The PhD project was conducted at the department of Clinical Sciences Lund, Ophthalmology, Skåne University Hospital, Sweden. The supervisors were Malin Malmsjö, M.D., Ph.D., Karl Engelsberg, M.D., Ph.D. and Sandra Lindstedt, M.D., Ph.D. at the Department of Clinical Sciences, Skåne University Hospital, Lund University.

Key points:

- Perfusion is higher in myocutaneous than in cutaneous flaps.
- In axial flaps, perfusion is maintained for longer flap lengths, suggesting that these flaps can be made longer than random flaps.
- Post-surgery, random flaps are more rapidly re-perfused than free skin grafts.
- Laser speckle contrast imaging enables perfusion monitoring during reconstructive surgery.

Introduction:

After tumor excision in the periocular area, tissue might be limited, and flaps or free, full-thickness skin grafts are often needed. The successful design of flaps and grafts is vital for the outcome and survival of the tissue. Therefore, the understanding of the vascular supply and reperfusion is critical. However, many surgical reconstructive techniques were developed before there was any objective way to monitor blood perfusion. Today, non-invasive, laser-based techniques, such as laser speckle contrast imaging (LSCI), can be used to monitor the perfusion in skin flaps and grafts. LSCI illuminates the tissue with a near-infrared laser and the interference pattern created by the backscattered light is used to determine perfusion, as the movement of red blood cells causes the pattern to change, allowing the blood perfusion to be quantified. In this thesis, LSCI was used to monitor the blood perfusion in human flaps and full-thickness skin grafts frequently used in periocular surgery. An axial flap is perfused by a specific blood vessel, while a random skin flap is not based on a specific vessel for its perfusion. Instead, its blood perfusion originates from the dermal plexus of the base of the flap. Oculoplastic surgery was used to assess the clinical implications of this novel bioimaging technique.

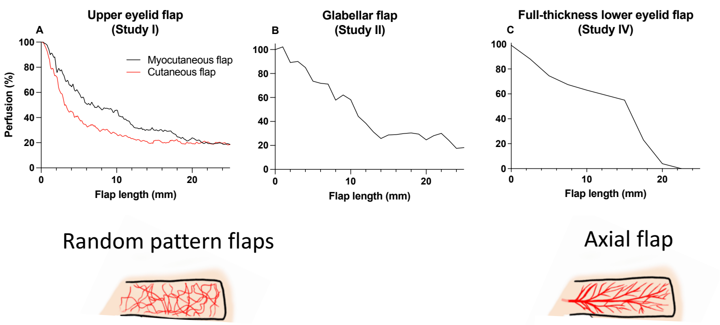

Figure 1. Perfusion shown as a percentage of a reference point near the flap base in upper eyelid flaps, glabellar flaps, and full-thickness lower eyelid flaps. The upper eyelid flaps (A) and the glabellar flaps (B) are random patterned flaps, while the full-thickness lower eyelid flaps (C) contain vessels of the marginal arcade and, therefore, can be seen as a model for axial flaps. Note that the decrease in perfusion was less pronounced in the axial flaps.

Future directions:

- Larger studies allowing subgroup analyses of factors known to affect blood perfusion, such as smoking and diabetes
- Monitoring the perfusion and reperfusion of flaps and skin grafts in other areas of the body
- Simultaneous monitoring of perfusion and oxygenation using laser speckle contrast imaging and hyperspectral imaging

Flap length:

The perfusion over the flap length during surgery was investigated on random flaps, without a specific blood vessel. In Study I, upper eyelid flaps were raised in patients undergoing blepharoplasty. The perfusion gradually decreased from the base to the tip of the flaps. Perfusion was better in myocutaneous flaps (including skin and orbicularis muscle), than in cutaneous flaps, where the muscle had been removed. Similar results were found in the glabellar flaps in Study II. The perfusion of the flaps in both studies was limited beyond 15 mm. Beyond this point, the flap resembled a free skin graft, that could, if necessary, be replaced with a free graft.

Axial vs. random patterned flaps:

Study IV was performed on axial flaps, containing an anatomically named blood vessel. Full-thickness lower eyelid flaps were raised as part of a modified Quickert procedure. The decrease in perfusion over the length of the flap was less pronounced than for the random flaps in Studies I and II (**Figure 1**). This indicates that axial flaps can be longer, while maintaining adequate perfusion.

Reperfusion:

The proximal parts of glabellar flaps (Study II) were rapidly re-perfused, within 1 week. Similar results were found in the reperfusion of random advancement flaps that were raised in a bipedicle advancement flaps procedure (Study III). In Study V, reperfusion of free full-thickness skin grafts took longer (7 weeks), probably as they, in contrast to the flaps, lacked a vascular connection and depended on de novo angiogenesis.

Conclusion:

LSCI enables detailed perfusion monitoring during and after periocular surgery. The periocular area is well-perfused, and it would be of value to monitor perfusion in less vascularized body areas. Further studies could lead to a deeper understanding of the healing process and provide opportunities to optimize surgical procedures.

References

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