Early skin graft necrosis delimitation by postoperative laser speckle analysis

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Short Report

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Abstract

Necrosis complicates up to 60% of skin grafts, but its extension might take several weeks to become fully established. Physical examination has poor accuracy in its early prediction. Laser speckle contrast imaging (LSCI) is a noncontact, in vivo, validated technology for the study of microcirculation of skin grafts. We sought to assess, in humans, if it is possible (with LSCI) to predict on day (D) 14 the extension of skin graft necrosis on D28.

Ten consecutive adult patients who underwent skin malignancy excision on the face (n=3), scalp (n=2), forearm (n=2), pretibial region (n=2) or plantar surface (n=1) and skin graft closure were included. Skin graft perfusion was assessed with LSCI on D14, and hypoperfused regions were highlighted. Clinical pictures of skin grafts on D28 were evaluated, and established necrotic regions were delimited. Then, we assessed whether hypoperfused regions identified on D14 overlapped, in location and size, with those regions of established clinical necrosis on D28.

Graft necrosis extension on D28 ranged from 0.5-21% on the face, 12-48% on the scalp, 0-15% on the forearm, 31-45% on the leg and 15% on the plantar surface. Approximately 89% (17 out of 19) of individual hypoperfused regions identified on D14 were also present on D28. The median extent of necrosis on D28 was 21% of the graft area, while on D14, hypoperfused regions corresponded to 23% (p=0.23).

We demonstrated that it is possible to predict and delimitate necrotic regions of skin grafts in a relatively early stage by LSCI. On D28, they extensively overlapped with the LSCI hypoperfused regions on D14. Therefore, we can identify the subset of patients at high risk of graft necrosis and anticipate the need for prolonged medical and wound care.

Introduction

Skin graft necrosis may take several weeks to become completely established, but there are no reliable clinical features that can predict its extension earlier in the healing process [1].

Laser speckle contrast imaging (LSCI) is a noncontact, in vivo, validated technology for the study of cutaneous microcirculation [2]. In dermatologic surgery, it has been recently employed in research on the vascularization of random pattern skin flaps and skin grafts [2–6]. To date, its ability to predict early skin graft necrosis is unknown. In this pilot study, we sought to assess whether it is possible to predict, on day 14, the extension of graft necrosis on day 28.

Methods

This study was approved by the local ethics committee. Ten consecutive adult patients who were proposed to full- or partial-thickness skin graft closure after skin cancer removal on the face (n = 3), scalp (n = 2), forearm (n = 2), leg (n = 2) or plantar region (n = 1) were enrolled, following informed consent. All
lesions were removed after infiltration of lidocaine (2%) with epinephrine (1:100,000). For facial and scalp defects, full-thickness skin grafts were harvested from the infraclavicular area. Split-thickness skin grafts were collected from the inner arm for forearm defect closure and from the anterior thigh for leg or plantar defects. Tie-over-dressing was applied for 1 week, and a new dressing with petrolatum gauze was applied thereafter, as required.

By day (D) 14 clinical and LSCI images were registered. Perfusion, in arbitrary perfusion units (APU), was first obtained and then divided by mean arterial pressure (MAP, mmHg), giving us the cutaneous vascular conductance (CVC, APU/mmHg).

LSCI provides images on a semiquantitative color scale, from black to red, where black and blue indicate no and low perfusion, respectively, and red indicates very intense perfusion. We used PIMSoft™ (version 1.5, 2013) to overlay clinical images recorded on D14 with hypoperfused (black to blue) regions identified by LSCI on D14 through a “filter of maximum perfusion intensity captured”. This filter was set according to the CVC of the grafts on day 14: CVC < 1, APU filter = 40; 1 ≤ CVC < 2, APU filter = 50; 2 ≤ CVC < 2.5, APU filter = 60; CVC ≥ 2.5, APU filter = 70.

Finally, we evaluated whether hypoperfused regions identified on D14 overlapped, in location and size, with those regions of established clinical necrosis on D28. The measurement of areas of hypoperfused and necrotic regions was performed with SketchAndCalc Area Calculator™ (version 6.2.5, 2018), and the Wilcoxon test was executed to assess significant differences between them. The significance level was set at < 0.05.

**Results**

The median age of the patients included was 81 y/o (ranging from 68-96 y/o), with 4 females and 6 males. Clinical pictures of all patients on D14 and D28 and speckle images on D14 are presented in Figures 1 and 2. A variable degree of necrosis was observed in all patients by D28, ranging from 0.5-21% on the face, 12-48% on the scalp, 0-15% on the dorsal aspect of the forearm, 31-45% on the anterior aspect of the leg and 15% on the plantar surface. When comparing clinical pictures on D28 with those on D14 with filter applied (of maximum perfusion intensity captured), we observed that necrosis extensively overlapped with the LSCI hypoperfused regions. Apart from the area, 17 out of 19 (89.4%) individual hypoperfused regions identified on D14 were also present on D28. The median extent of necrosis on D28 was 14% of the graft area, while on D14, hypoperfused regions corresponded to 15% of the graft area. This difference was not statistically significant (p=0.23).

**Discussion**

Much of the knowledge about skin graft microcirculation comes from animal studies, and the hallmark research performed in humans relies on stereoscopic or electronic microscopy analysis of graft biopsy specimens, especially after burns [7]. This posed the following limitations: i) animal and human findings
during the graft healing process might not correlate; ii) most of the research focused on characterization of the inosculocation phase and did not evaluate beyond the first 7–10 days of graft healing; iii) *in vivo* assessment of vascularization in the dermato-oncological setting was not possible, noninvasively and contactless, until recently [3, 7].

Necrosis may complicate 5–66% of skin grafts, depending on the location and type of graft, and very often requires prolonged medical attention, with repeated wound dressing, careful debridement, or even regrafting [8, 9].

Thus far, we could only rely on physical examination, with its limitations, for predicting skin graft perfusion and evolution. For instance, the acquisition of pink color in the first week is generally considered a sign of probable graft survival, but the intensity of coloration does not allow us to infer graft perfusion status [7].

We believe this pilot study is the first to show that it is possible to predict and delimitate necrotic regions of skin grafts in a relatively early stage by laser speckle. We did not find any statistically significant differences in graft necrosis areas delimited on D14 by LSCI and in the actual necrosis areas clinically observed on D28.

The choice of D14 and D28 as “checkpoints” was not arbitrary. In a recent retrospective cohort study, it was shown that the number of grafts counted as taken decreased from week 1 to week 4, and this number was still not stabilized by week 2 (especially in the case of full-thickness grafts) [1]. Moreover, in a previous exploratory study, we demonstrated that on D14, skin graft perfusion, assessed by LSCI, is almost equivalent to normal control skin. By D28, perfusion overcame control skin perfusion, and graft necrosis was well established [1].

In clinical practice, our findings can be relevant since, very often, graft stitches are removed at approximately D14, and patients ask the surgeon about graft prognosis. Hence, we considered this time opportune to predict later necrosis extension and anticipate the need for medical and wound care.

The present research has several limitations. We did not consider patient-related variables such as age, cardiovascular disease risk factors, anticoagulant medication, differences in type of skin graft or wound anatomic location. The small-sized sample does not allow a large-scale extrapolation. Future studies are required to validate these findings.

In conclusion, we were able to demonstrate that hypoperfused graft regions identified on D14 by LSCI overlap graft necrosis regions on D28.

**Declarations**

**Conflict of interest disclosure**: The authors have no financial interest to declare in relation to the contents or products mentioned in this article.
MD Pinho, A has nothing to disclose.

MD-PhD Brinca, A has nothing to disclose.

MD-PhD Vieira, R has nothing to disclose.

References


Figures
Clinical images on D14 and on D28 of patients submitted to full-thickness skin grafting on the face or scalp. Blue and black areas on LSCI images on D14 indicate hypoperfused regions. When a perfusion filter is applied and LSCI and clinical images are overlaid, on D14, hypoperfused regions are best highlighted. These regions overlap established necrotic regions on D28. APU, arbitrary perfusion units, D (day), LSCI (laser speckle control imaging).
Figure 2

Clinical and LSCI images on D14 and clinical images on D28 of patients submitted to split-thickness skin grafting on the dorsal aspect of the forearm, pretibial region, or plantar surface. APU, arbitrary perfusion units, D (day), LSCI (laser speckle control imaging).