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Reconstructive

Characteristics and Limitations of Video-capillaroscopy in Reconstructive Microsurgery for Different Histologic Components of Flaps

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Summary: Indocyanine green, ultrasonography, and handheld Doppler can be used to evaluate blood flow at the donor and recipient site during microvascular reconstruction. However, these methods do not provide direct visualization and assessment of real-time blood flow. Video-capillaroscopy has been shown to be useful in clinical practice to assess microcirculation in rheumatologic disorders. In this report we used video-capillaroscopy to assess different tissue components involved in microvascular surgery. Seven patients who underwent head and neck oncologic microvascular reconstruction between November 2021 and February 2022 were included in this study. Video-capillaroscopy (GOKO-BscanZD, GOKO Imaging Devices Co., Ltd., Japan) was used to evaluate the donor-site and recipient-site tissue components. Optimal red blood cell movement was graded with a score of four, while no flow was graded with a score of 0. Seven myocutaneous flaps and seven recipient sites were evaluated. For the donor-site, our analysis demonstrated a significantly higher video-capillaroscopy quality for skin (3.43), adipose tissue (3.7) and perforators (3.7) when compared with muscle (0.429), muscle fascia (0.857), and de-epithelialized skin (1) ($P < 0.001$). For the recipient-site, a significantly higher video-capillaroscopy quality for skin (2.7), adipose tissue (3.5), and the periosteum (2.1) was noted when compared with muscle (0) ($P < 0.001$). Video-capillaroscopy efficiency is limited in the muscular component and injured (de-epithelialized) skin surface areas of flaps. Herein, we provide evidence that assessment of flap perfusion with video-capillaroscopy can be reliably achieved in the skin, periosteum, perforators, and adipose tissue. Video-capillaroscopy is expected to be applied for intraoperative real-time blood flow evaluation. *(Plast Reconstr Surg Glob Open 2022;10:e4583; doi: 10.1097/GOX.0000000000004583; Published online 1 November 2022.)*

INTRODUCTION

With microsurgery, surgeons can transfer vascularized tissue to any anatomical unit requiring reconstruction.[1]

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Indocyanine green (ICG), ultrasonography, and handheld Doppler can be used to assess blood flow at the donor- and recipient-site.[1,2] However, ICG-angiography is invasive and requires contrast agent administration, ultrasound is operator-dependent and bone may generate artefacts, and handheld Doppler may pick up emitted sounds from surrounding vessels.

Video-capillaroscopy is a well-known, noninvasive diagnostic modality to assess microcirculation in the field of rheumatology.[3] Previously, we have successfully captured real-time blood flow for flap perfusion assessment within 1-mm depth from the superficial layer using video-capillaroscopy.[4–6] Herein, we used video-capillaroscopy to assess different tissue components involved in

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microvascular surgery. Additionally, we reported the characteristics of our findings and conditions limiting the use of video-capillaroscopy.

MATERIALS AND METHODS

This study was approved by the institutional review board (IRB no.: 241). Seven patients (four men and three women) between the ages of 54 and 76 years underwent head and neck oncologic microvascular reconstruction from November 2021 to February 2022. We excluded patients with a diagnosis of coagulopathy. Video-capillaroscopy (GOKO-BscanZD,GOKO Imaging Devices Co., Japan) was used in the central region of four evenly divided areas (quartiles) of each donor- and recipient-site tissue components. (**See figure, Supplemental Digital Content 1,** which displays donor-site and recipient-site areas evenly divided into four areas for observation. The central portion in each area is evaluated with video-capillaroscopy. All observations with video-capillaroscopy in the donor-site were determined before transecting the pedicle. **http://links.lww.com/PRSGO/C183.**)

At the donor site (flap), the muscle, fascia, skin surface, adipose tissue, de-epithelialized skin, and perforators were observed in each patient before pedicle transection. A total of 25 perforating branches were observed at the junction of the blood vessels and fascia (3.57 perforators per flap). In the recipient site, the cervical skin, mandibular periosteum, sternocleidomastoid muscle, and cervical adipose tissue were observed. Blood flow was defined as clear observation of red blood cell movement. A four-point evaluation scale was used to determine blood flow on video-capillaroscopy. Zero points were given if blood flow was not observed. One, two, three, and four points were given if blood flow was observed in less than 25%, 25–50%, 50–75%, and greater than 75% of the observed areas, respectively. Papaverine hydrochloride was used to prevent perforator spasm.

RESULTS

Two rectus abdominis myocutaneous flaps (28.6%), five anterolateral thigh-vastus lateralis (ALT-VL) flaps (71.4%), and seven recipient sites (100%) were evaluated. The mean video-capillaroscopy scores for donor site muscle (0.429 ± 0.535), fascia (0.857 ± 0.9), de-epithelialized skin (1.0 ± 0.816), skin paddle (3.429 ± 0.535), adipose tissue (3.714 ± 0.488), and perforators (4.0 ± 0.0) are exhibited in Table 1. Post-hoc analysis demonstrated a significantly higher video-capillaroscopy quality for skin, adipose tissue, and perforators when compared with muscle, fascia, or de-epithelialized skin ($P < 0.001$) (Fig. 1).

The mean scores for recipient-site muscle (0.0 ± 0.0), periosteum (2.143 ± 0.69), skin (2.714 ± 0.488), and adipose tissue (3.571 ± 0.535) are shown in Table 1. Post-hoc analysis demonstrated a significantly higher video-capillaroscopy quality for skin, adipose tissue, and periosteum when compared with muscle ($P < 0.001$). We also found a significantly higher video-capillaroscopy quality for adipose tissue when compared with the periosteum ($P = 0.005$) and skin ($P = 0.038$) at the recipient-site.

Takeaways

Question: Can video-capillaroscopy detect the capillary microcirculation from different histologic components of free flaps for intraoperative and postoperative perfusion assessment with the same accuracy and effectiveness?

Findings: Seven myocutaneous flaps and seven recipient sites were evaluated. A significantly higher video-capillaroscopy quality was evident for perfusion assessment of the skin, adipose tissue, perforators, and periosteum when compared with muscle, muscle fascia, and de-epithelialized skin.

Meaning: Assessment of flaps' capillary microcirculation with video-capillaroscopy can be reliably achieved in periosteum, perforators, and adipose tissue during intraoperative flap assessment and in the skin during postoperative and intraoperative flap evaluation.

Table 1. Scores of the Different Tissue Components for Donor-site and Recipient-site

Zone	Mean ± SD	Standard Error (σ_M)
Flap observation		
Muscle	0.429 ± 0.535	0.202
Muscle fascia	0.857 ± 0.9	0.34
Skin papillary	3.429 ± 0.535	0.202
Adipose tissue papillary	3.714 ± 0.488	0.184
Perforator	4 ± 0	0
De-epithelialized skin	1 ± 0.816	0.309
Recipient site observation		
Skin papillary	2.714 ± 0.488	0.184
Muscle	0 ± 0	0
Adipose tissue papillary	3.571 ± 0.535	0.202
Periosteum	2.143 ± 0.69	0.261

To evaluate precision and consistency among anatomical areas, we compared the video-capillaroscopy findings for skin, muscle, and adipose tissue between the flap (donor-site) and recipient-site. We found a significant difference between the observations of flaps and recipient sites for the skin (3.429 versus 2.714, $P = 0.036$). We did not find a significant difference between the observations of the flap and the recipient site for muscle ($P = 0.073$) and adipose tissue ($P = 0.645$).

DISCUSSION

Video-capillaroscopy is a noninvasive imaging modality that can be used to assess perfusion changes in the capillary microcirculation of flaps.[4,5] Nonetheless, its application during microsurgery can be limited due to the different histological features of certain flap components. For instance, in the skin papillary region, video-capillaroscopy evaluation near to the incisions was not possible. Likewise, assessment via video-capillaroscopy was intractable for muscles and fascia due to poor LED penetration. Video-capillaroscopy for de-epithelialized skin was also inadequate due to damage within 1-mm depth from the surface. Finally, blood flow could be observed over the periosteum in areas where no superficial injury was evident. [**See Video (online)**, which

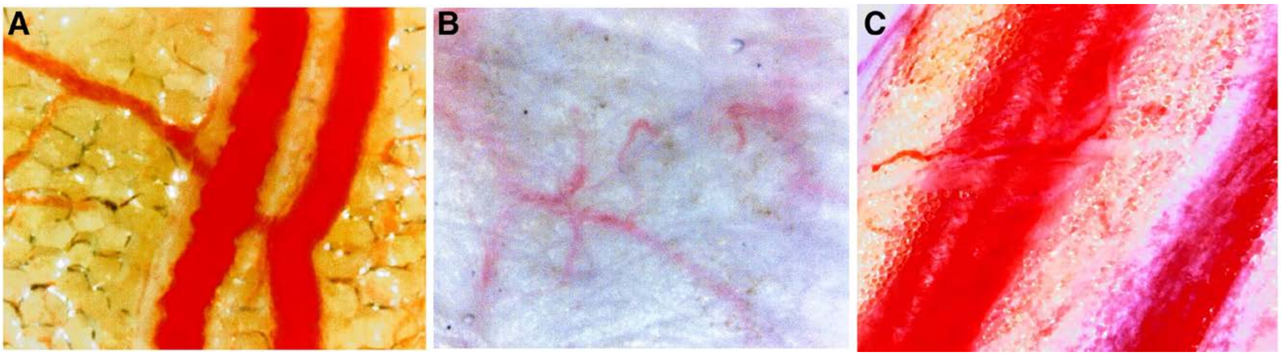

Fig. 1. Video-capillaroscopy assessment of the adipose tissue (A), skin (B), and perforators (C).

displays how video-capillaroscopy comprises a combined synergistic system of a capillaroscope (microscope) and LED capable of providing non-invasive real-time observation of the movement of red blood cells (RBCs) in capillaries. This video demonstrates the best observations that we could evidence with video-capillaroscopy for the capillaries skin, flap perforator, subcutaneous tissue, muscle surface, and fascia.]

When compared with muscle, in which capillaroscopy is problematic as most capillary networks rest within the endomysium,[7] bones have extensive vascular connections between the bone marrow, cortex, and the capillary network within the osteogenic layer of the periosteum. The latter is effectively evaluated with video-capillaroscopy.[8] In cases of osteomyelitis, radiation, or severe trauma, video-capillaroscopy can help estimate the amount of bone that needs to be resected/debrided by evaluating the microcirculatory status of the recipient site. Given that video-capillaroscopy has a moderate-to-good accuracy for periosteum, a cautelous approach is recommended for this purpose.

Also, with video-capillaroscopy hypoperfused areas of fasciocutaneous or osteocutaneous flaps can be selectively excised intraoperatively anticipating future wound-related complications. On this matter, rows of capillaries in the subcutaneous tissue run mostly in parallel direction; therefore, video-capillaroscopy of adipose tissue allowed for better assessment of rheological features of capillaries when compared to the skin.[9] On the other hand, the skin superabounds in capillaries, most of them arranged perpendicularly to the skin surface where solely the tip of the loop is usually detectable.[9] In this setting, video-capillaroscopy can be implemented for postoperative flap monitoring after inset if the skin paddle is intact when fasciocutaneous flaps are used.[10]

It is worth highlighting that video-capillaroscopy shares some disadvantages with other assessment modalities. For instance, in the case of pharyngeal reconstruction where flaps cannot be visualized, or if an abdominal-based flap is de-epithelialized and completely covered by the native mastectomy flaps, direct contact of the capillaroscope with the transplanted tissue is limited and evaluation cannot be performed. As a limitation of this study, we are not certain about the effect of radiotherapy on video-capillaroscopy readings, as only two patients had neoadjuvant radiotherapy.[9] Finally, the limited sample size may affect the possibility of finding additional statistically significant associations.

CONCLUSIONS

The utility of video-capillaroscopy is limited in the muscular component and injured areas within 1-mm depth. Optimal video-capillaroscopy observations for perfusion are achieved in the skin, periosteum, perforators, and adipose tissue, with the latter demonstrating more consistent results. Further studies are required to evaluate the effectiveness and validity of this assessment tool when compared with other contemporary perfusion assessment modalities.

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