Real-Time Visualization of Blood Flow for Free Flap Monitoring Using a Smartphone Application

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BACKGROUND: Free flap monitoring is of paramount importance to ensure that the vascular supply is not compromised over a patient's postoperative course. Early detection of arterial or venous failure facilitates salvage. The ideal monitoring system has been described as continuous, non-invasive, quantitative, easy to administer, highly sensitive, and highly specific.[1] A variety of currently used technologies provide proxies to assess flap perfusion, however are expensive and fall short of the ideals. Other attempts at using smartphones for microsurgical free flaps[2] do not provide real-time monitoring.

METHODS: We have developed an Android-based smartphone application that utilizes the Eulerian Video Magnification (EVM)[3] algorithm to directly visualize skin perfusion of non-buried free flaps in real-time and provides immediate analysis of tissue. The EVM algorithm allows us to amplify small changes that are not discernable to the human eye, such as the change in color of skin in systole and diastole. Our application has modified this algorithm to assess arterial and venous occlusion in models using hands with various applied tourniquet pressures.

RESULTS: This smartphone application enables the visualization of perfusion to the skin (Fig. 1). Our testing shows that we can both qualitatively and quantitatively identify arterial occlusion and venous occlusion in our simulated environments. We have also demonstrated its use intraoperatively and postoperatively for free flap monitoring.

DISCUSSION: This serves as proof-of-concept for real-time, non-invasive monitoring of microsurgical free flaps with a smartphone. Our application meets many of the requirements of the ideal monitoring system: continuous (real-time), non-invasive, quantitative and easy to administer. This is the basis for a multi-institutional study to assess sensitivity and specificity in free flaps compared to other widely adopted technologies.

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FIGURE LEGEND:

Figure 1. Screenshot of video output from smartphone application of a human hand showing magnification of blood flow in systole.