Original Article

Thermographic Mapping of Arterial Perforators in the Leg

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Abstract

Background: Preoperative localisation of perforators aids in easy intraoperative dissection. Infrared thermography is a simple, safe, and effective tool with a short learning curve that is useful in identifying perforators. It has been found to have a high concordance rate when compared with computed tomography angiography and is useful in identifying arterial perforators in the leg. **Objectives:** To create a thermographic map of arterial perforators in the leg and to determine the correlation between the number of perforators identified and the length of the leg. **Materials and Methods:** This was a cross-sectional study. The length of the leg was measured and the location of perforators corresponding to the distribution of the anterior tibial, posterior tibial, and peroneal arteries was identified using thermography. The mean number of perforators corresponding to the different surfaces of the leg was noted, this was then correlated with the length of the leg using the Pearson correlation coefficient. **Results:** Using thermography, perforators were identified along a line drawn from the medial malleolus to the medial tibia plateau and from the lateral malleolus to the head of the fibula and within 2 cm of these lines. More perforators were found in the middle third of the leg and there was no significant correlation between the number of perforators and the length of the leg. **Conclusion:** A useful surface marking to aid the identification of perforators in the leg using infrared thermography was found. There was no significant correlation between the length of the leg and the number of perforators.

Keywords: *Correlation, mapping, perforators, thermography*

Introduction

Accurate preoperative identification of perforators in the leg aids designing of perforator flaps, makes intraoperative dissection easier, and improves the chances of success of these flaps.[1] Various authors have described anatomical landmarks in the leg to aid the easy identification of perforators; however, individual variation in the location of perforators is the rule rather than the exception.[2] Different radiological investigations have been employed to help localise and determine the size and calibre and the intraoperative course of these perforators, chief among these is computed tomography angiography (CTA).[3] Other modalities include magnetic resonance angiography (MRA), colour Doppler ultrasound (CDU), handheld acoustic Doppler devices, and infrared thermography.[4]

The use of infrared thermography to identify perforators was first described by Thuvert *et al*.[5] in 1985. Since then it has been used to identify perforators and aid in the design of perforator flaps in different parts of the body including the leg.[6,7] Infrared cameras are easy to use, portable (smartphone-compatible devices are available), relatively cheap, and has a shallow learning curve.[8] They also have a high-concordance rate when compared to the CTA in locating perforators in the anterolateral thigh area.[9] The infrared camera works on the principle that all objects above absolute zero temperature emit infrared radiation, the hotter the object the greater the amount of radiation.[10] The area of skin supplied by perforators is perfused first and is therefore hotter compared to other areas and this can be enhanced using a cold challenge that cools an area of skin and then allows it to rewarm.[11]

Boriani *et al*.[12] in their study described a positive correlation between the length of the leg and the number of perforators identified suggesting that perforator flaps based on a single perforator were more likely to be safely raised in a "shorter" leg.

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In a longer leg, such flaps may require the incorporation of additional perforators.

Though there are various publications describing the use of the infrared camera to locate and design perforator flaps in the leg[7,13]and also to describe the location of venous perforators in the leg,[14] there is sparse literature on the description of arterial perforators in the entire leg area using infrared thermography. We believe that this description will ease the localisation of perforators in the leg and thus aid the planning and design of perforator flaps in the leg.

We, therefore, aim to create a thermographic map of perforators in the leg using the infrared camera and to determine the correlation between the length of the leg and the number of perforators identified by thermography.

Materials and Methods

This study was carried out in the Department of Plastic, Reconstructive, and Aesthetic Surgery, University College Hospital, Ibadan, Nigeria. Participants included students and patients of the department. This was a cross-sectional study and was carried out between April and July 2021. The inclusion criterion was a willingness to participate in the study, participants who had previous lower limb reconstruction, fever, tumours, sickle cell disease, and diabetes mellitus were excluded from the study. Ethical approval was obtained from the University of Ibadan/University College Hospital ethics committee.

Participants were asked to lie supine on a couch and expose their legs for 5 min, the length of the leg was measured from the tibia tuberosity to the inter-malleoli line, and the leg was divided into thirds, isopropyl alcohol was applied to the leg allowing it to evaporate thereby cooling the skin. The infrared camera, the FLIR ONE (FLIR Systems, Inc., Wilsonville, OR) was switched on and connected to an iPad device (Apple, California Model A2153, Apple Inc., CA, USA) that has the FLIR ONE software downloaded and installed from the Apple store and this was set at about 60 cm over each area and the leg was allowed to rewarm. Areas where perforators were located appeared as hot spots (yellow spots) and these areas were marked with a red marker. Photographs of the markings on the leg were taken with an iPad device. These spots were interrogated with a handheld acoustic Doppler device (HI. dop BT-200 vascular Doppler with 8 MHz probe) for audible Doppler sounds.

The mean number of perforators identified by thermography on the anterolateral, posterolateral, and medial surfaces of the leg was noted, and the percentage number of perforators with audible Doppler signals was also noted. Pearson correlation coefficient was used to determine the correlation between the length of the leg and the number of perforators identified.

Results

Fifty-five legs of forty-four participants (19 males and 25 females) were examined in this study. The age range of the participants was 14–60 years old with a mean age of 27.4 ± 9.2 years. Twenty left legs were examined whereas the number of right legs were thirty-five. The length of the leg measured from the tibial tuberosity to the intermalleolar line ranged from 31 to 40 cm with a mean length of 35.1 ± 1.82 cm.

The mean number of perforators identified by infrared thermography on the anterolateral surface of the leg was 10.27 ± 4.28 (3.53 ± 1.95 in the upper third, 4.02 ± 2.41 in the middle third, and 2.84 ± 1.61 in the lower third), 8.65 ± 4.88 on the posterolateral surface of the leg (2.89 ± 2.42 in the upper third, 3.62 ± 2.47 in the middle third and 2.18 ± 1.76 in the lower third), and 15.85 ± 7.12 on the medial surface of the leg (4.98 ± 2.52 in the upper third, 5.98 ± 3.50 in the middle third and 4.84 ± 2.66 in the lower third).

A cluster of perforators was usually found along a line drawn from the medial malleolus to the medial tibia plateau on the medial surface of the leg and along a similar line drawn from the lateral malleolus to the fibula head on the lateral surface. Perforators were also found about 2 cm on either of these lines as shown in Figures 1 and 2.

Areas marked as having perforators were interrogated with the handheld Doppler, 99% of the perforators on the medial surface of the leg had corresponding audible Doppler signals whereas 93% of perforators on the anterolateral and posterolateral surfaces of the leg had audible signals.

The number of perforators identified by thermography correlated positively with the length of the leg on the anterolateral surface though this was not statistically significant. On the posterolateral and medial surfaces of the leg, there was a negative correlation with the length of the leg and this also was not statistically significant as shown in Table 1.

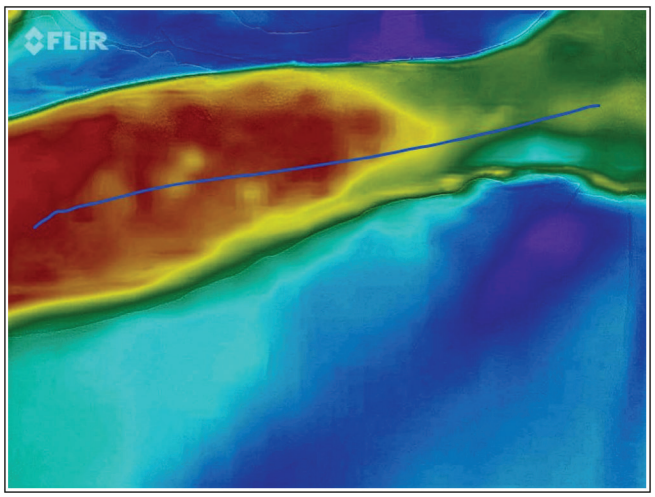

Figure 1: A thermographic image of the lateral surface of a leg showing a colour palette representing the temperature of different areas of the leg after a cold challenge. Yellow spots "hot spots" represent the location of perforators. Blue line represents the surface marking from the lateral malleolus to the fibula head

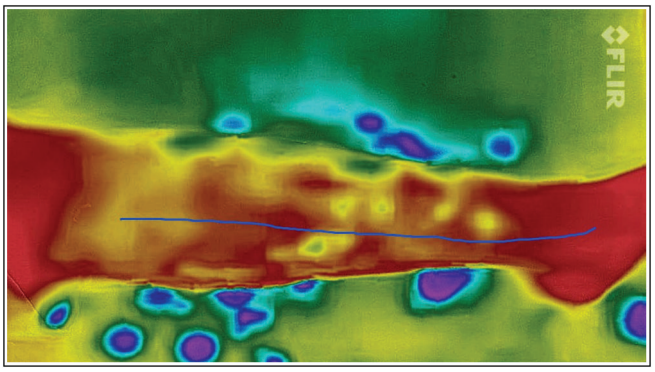

Figure 2: A thermographic image of the medial surface of a leg showing a colour palette representing the temperature of different areas of the leg after a cold challenge. Yellow spots "hot spots" represent the location of perforators. Blue line represents the surface marking from the medial malleolus to the medial tibial plateau

Table 1: Correlation between the number of perforators and length of the leg

Surface of the leg	Correlation coefficient	*P*-value
Anterolateral surface	0.165	0.228
Posterolateral surface	−0.087	0.526
Medial surface	−0.135	0.324

Discussion

Though CTA remains the gold standard for the preoperative identification of perforators, infrared thermography has been shown to give results comparable to that of the CTA.[3]

In this study, infrared thermography identified a higher number of perforators in the middle third of the leg on all the surfaces examined, also a cluster of perforators was found along a line drawn from the medial malleolus to the medial tibia plateau and also along a line drawn from the lateral malleolus to the head of the fibula and 2 cm on either side of these lines. There was no significant correlation between the length of the leg and the number of perforators.

The findings from this study suggest that a good place to start the search for perforators in the leg using infrared thermography is in the middle third of the leg and along the surface markings described above. This study also shows that there is no correlation between the length of the leg and the number of perforators identified by thermography.

The surface landmark described above may be related to the location of septocutaneous perforators present in the intermuscular septa separating the different compartments of the leg. On the anterolateral surface of the leg, this will correspond to the septa separating the anterior and lateral compartment of the leg,[15] whereas on the medial surface of the leg, this will correspond to the septa separating the soleus from the muscles in the deep posterior compartment of the leg.[16]

There are other published studies that have described the location of perforators in the leg in relation to the source vessels and landmarks in the leg such as the medial and lateral malleolus and the intermalleolar line.

The anatomic study by Schaverien *et al*.[17] used 20 lower limb cadavers (15 were injected with coloured latex and dissected and 5 were injected with barium sulphate/gelatine mixture and computed tomography scans were obtained). Clusters of perforators (diameter ≥ 0.5 cm) were found at regular 5 cm intervals, with those from the anterior tibia artery found mainly at the 4 to 9 cm and 21 to 26 cm distance from the intermalleolar line. Those from the peroneal artery at the 13 cm to 18 cm distance from the lateral malleolus whereas those from the posterior tibia artery were clustered at the 4–9 cm, 13–18 cm, and 21–26 cm distance from the medial malleolus.

In the cadaveric study by Tapadar *et al*.[18] 20 legs were dissected. Perforators arising from the anterior tibial artery were found to be clustered in the upper and middle third of the leg, the majority of perforators from the posterior tibia artery were in the middle one-third of the leg while the perforators from the peroneal artery were distributed all along the posterior intermuscular septa.

Martin *et al*.[19] in their study of cutaneous perforators of the leg using CTA in five lead oxide injected cadavers observed that perforators from the anterior tibial artery were clustered at three levels, 28%, 59%, and 83% of leg length from the ankle to the knee, those from the peroneal artery where clustered at 27% and 61% of leg length from the lateral malleolus while those from the posterior tibial artery were centred at 23% and 56% of leg length from the medial malleolus.

Paul *et al*.[14] in their study to identify perforators in the leg using thermography examined 23 patients and found hot spots relating to perforators of the anterior tibial artery at 5–10 cm and 20–25 cm interval from the intermalleolar line and those from the peroneal artery were at the 13–18 cm intervals from the intermalleolar line.

Our study describes the concentration of perforators on the different surfaces of the entire leg using thermography and provides a useful guide for the identification of perforators in the leg using thermography.

Even though infrared thermography has a high sensitivity in locating perforators its specificity is not known.[20] A limitation of this study was that the perforators identified by thermography were not corroborated with the gold standard (e.g., CTA) or intraoperative findings.

Conclusion

To conclude a useful guide using infrared thermography to identify perforators in the leg would be along and within 2 cm of a line drawn from the medial malleolus to the medial tibia plateau and from the lateral malleolus to the head of the fibula. The majority of these perforators will be found

in the middle third of the leg. No significant correlation was found between perforators identified by thermography and the length of the leg.

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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