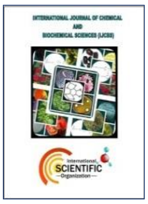
International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html



Correlation between Size and Blood flow in a Perforator and the Dimensions of a Perforator Flap in Lower Limb Reconstruction; a Cohort Study

***Yehia K. M. El-Refaie*[1*], *Tarek Mahboub*[2], *Khaled EL Kaffas*[3] *Omar M. Nouh*[4]**

[1] *Assistant Lecturer of Plastic and Reconstructive Surgery, General surgery department, Cairo University, Egypt.*

[2] *Professor of Plastic and Reconstructive Surgery, General Surgery Department, Cairo University, Egypt.*

[3] *Professor of Radiology, Diagnostic and Interventional Radiology Department, Cairo University, Egypt.*

[4] *Lecturer of Plastic and Reconstructive Surgery, General Surgery Department, Cairo University, Egypt.*

Abstract

Perforator flaps are essential tools in the armament of reconstructive surgeons during lower limb reconstruction. However, these have been complicated by partial loss, owing to the lack of defining dimensions for the respective perforasomes. This study aimed at finding a mathematical correlation between specific perforator characteristics, its diameter and peak systolic velocity, and the amount of tissue it can safely carry as a flap. 26 patients with post-traumatic lower limb defects were enrolled in this cohort. All patients underwent duplex ultrasound to mark the perforators, determine their diameter, and measure the Peak systolic Velocity. Perforator flaps were used to cover the defects. Surviving flap dimensions were taken in addition to the peak Systolic velocity of the perforator used and a proposed correlation was formulated. For the 24 surviving flaps, no linear correlation was found between the peak systolic velocity nor the perforator diameter to the surviving flap dimensions. By formulating a neo-equation including both variables and a constant a statistically significant correlation was found (*p-value* <0.01). The preliminary equation allows predicting the flap surface area that can be safely carried on a particular perforator based on the peak Systolic Velocity and the perforator diameter.

Keywords:

Full length article **Corresponding Author*, e-mail: yehia7@hotmail.com

1. Introduction

Ever since the first perforator flap was put forward in 1989, perforator flaps have seen a lot of advancements and innovations over the years making them basically available for use in the whole body and for most types of defects [1-5]. However, with the use of larger single perforator flaps, complications have begun to show [6-7]. There was no clear demarcation point at which surgeons know whether this perforator will carry this flap safely or not. Studies have been done studying the vascular territories of the axial vessels and their perforators, yet nothing perforator specific in the lower extremity [8-9]. This higher complication rate is attributed usually to vascular insufficiency, yet some cases, even with a proper technique, complicate and require a larger reconstruction than originally necessary. This is usually caused by the larger flap surface area that was carried on the available perforator. Although possibly within the theoretical maximum described in literature, there are many reported cases of partial or complete flap loss that cannot be explained. Up to this date there is still no accurate estimative tool of the safe pre-operative perforator flap dimensions that can be tailored to each individual. The literature shows trials by some surgeons to attend to this particular problem by correlating the flap dimensions with the chosen perforator to base it upon, however these trials were mainly focused on the DIEP flap used for breast reconstruction and not the lower limb [7,10-13]. Color coded duplex (CCD) is a very useful tool when studying a particular perforator. Not only can it delineate the site of the perforator and its nature whether septocutaneous or musculocutaneous, it can also provide essential data including the intramuscular course of the perforator, the diameter or the perforator and the flow velocity in the perforator and the source vessel [14].

It has the advantage of being simple, non-invasive and accurate in good hands [15]. In addition, the data provided by CCD can decrease operative time by up to 60 minutes [16]. The main disadvantage of CCD is that its highly operator dependent and can yield false data with improper technique and lack of experienced radiologists [15]. Lower limb defects tend to require flap reconstruction, owing to the lack of soft tissue padding in the distal lower limb, and the subcutaneous nature of bones making them readily exposed mandating vascularized coverage. Perforator flaps is frequently put to action when dealing with post-traumatic lower limb defects. popular options include anterolateral and anteromedial thigh flaps, genicular artery perforator flaps, posterior tibial, anterior tibial and peroneal perforator flaps, the sural flap and medial plantar flaps [17-18].

2. Methods

The study was conducted between April 2021 and January 2023 at the institution of the authors. It was designed as a prospective cohort study including 26 patients presenting with lower limb defects needing flap coverage. This study was granted an ethical committee approval coded MD-213-2021. Patients aged from 4 to 70 years old, presenting with lower limb defects amenable for local flap coverage, were included in this study. Morbidly obese patients and patients with uncontrolled medical comorbidities (hypertension, diabetes mellites, collagen vascular disease, etc..), patients with chronic venous insufficiency and patients who received radiotherapy to the affected limb were excluded. Upon completing the primary and secondary surveys, patients were admitted to the plastic surgery department. Necessary debridement was done to all patient till the defect is deemed ready for coverage. Negative pressure wound therapy was used to bridge the wounds from admission till definitive surgery is undertaken. In cases presenting with open fractures, external fixation was done prior to definitive coverage. Patients were referred to the Radiology department to have the duplex done. This study relied on the ability of the radiologist to identify the main axial vessels of the part of the limb to be examined, measure their diameters and peak systolic velocity (PSV), identify the cutaneous perforators of these axial vessels, mark them on the skin surface opposite their origin with documentation of their respective diameters and PSVs. The exact site of each perforator was also documented in relation to fixed bony landmarks such as the medial and lateral malleoli for example. Based on this information, the next step of perforator flap design and execution could be safely planned. Patients/their legal guardians were counselled regarding their condition, its sequels, proposed treatment plan and the rationale behind them. Written consents were signed prior to any operative intervention with particular emphasis on possible complications, e.g. flap loss. Separate written consents were signed by the patients with acceptance to take part of this study and permission to use their photos for research and publishing purposes. Guided by the duplex markings, the perforator locations were confirmed by a handheld Doppler device. Depending on the site of the recipient raw area and the location of perforators in its vicinity, a perforator flap was planned. Under tourniquet control, the recipient site was prepared, and its dimensions confirmed with the flap design. Next an exploratory incision was made on one side of the flap opposite the chosen perforator in order to assess it under vision for its fitness to carry the flap. Criteria that were assessed were:

1. Visible pulsations (after tourniquet deflation).
2. Proper diameter of the perforator, which was measured intraoperatively with a special ruler (Figure 1).
3. Arborization within the flap (seen with transillumination).

The flap was then elevated in a subfascial plane according to the previous proposed design (Figure 1). After complete elevation, the flap was hinged on all encountered perforators and a last assessment between all of them was done. When the original perforator was found fit, others were sacrificed, if they interfered with tensionless rotation and inset of the flap. Before flap inset, tourniquet was deflated to confirm flap viability, the flap was inset into the recipient defect and secured in place by simple sutures. Finally, rubber drains were inserted in dependent positions. As regards the donor site, if the resulting defect could not be closed primarily, it was grafted using a split thickness skin graft. Post-operatively, the flaps were clinically monitored regarding the color, warmth and capillary refill every 4 hours for the first 48 hours, then twice daily for the next five days. In case no complications were observed, and the patients were cleared for discharge by other involved specialties patients were discharged and followed up weekly in the outpatient clinic, for dressing change. Sutures were usually removed on day 21. Upon completion of follow up the dimensions of surviving flaps and the diameter and PSV of the perforator used were recorded. Finally, complications, functional and aesthetic outcomes were noted. The proposed correlation between the diameter and PSV of the perforator and the possible flap dimensions was then formulated as follows:

$$d \times PSV = \frac{maximum\ possible\ flap\ surface\ area\ in\ cm^2}{\pi}$$

In this equation, d represents the perforator diameter, PSV its peak systolic velocity and π the coefficient needed. The proposed flap surface area was also expressed by the following equation:

$$maximum\ possible\ flap\ length = \frac{proposed\ maximum\ flap\ surface\ are\ in\ cm^2}{maximum\ possible\ flap\ width\ in\ literature}$$

In order to calculate the maximum possible flap length, the proposed maximum surface area resulting from the first equation was divided by the maximum width of the given flap in the literature.

The length was chosen to be the variable in this equation, as the axis of lower limb flaps is longitudinal owning to the course of the main vessels, and thus the perforators are arranged in a longitudinal manner. The maximum width of each angiosome can be seen as constant, while the length relies on distance between each perforator and possibly its size.

Patients presenting with functional or aesthetic complaints following completion of reconstruction were re-admitted for touch up procedures, such as flap debulking, separation of a peninsular flap or refashioning of dog ears or to deal with complications, such as partial flap loss. Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 28 (IBM Corp., Armonk, NY, USA). Data was summarized using mean, standard deviation, median, minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. Comparisons between quantitative variables were done using the non-parametric Mann-Whitney test [19]. For comparing categorical data, Chi square (x^2) test was performed. Exact test was used instead when the expected frequency is less than 5 [20]. P-values less than 0.05 were considered statistically significant.

3. Results and Discussion

The data collected and analyzed were grouped into two main categories; one being the usual statistical analysis and the other being a trial at validation of the novel equation. The study population was originally composed of 26 patients, yet 2 of the flaps suffered complete necrosis. Thus, these were excluded from the statistical validation of the new equation. However, they were included in the demographics and complications and total count for completeness. The study population comprised 20 males and 6 females. 23 had no known medical comorbidities, while two were medically controlled diabetics and 1 had controlled diabetes and hypertension. The mean age for the study population was 25.67. The defects were then analyzed based on site (figure 2) and size. The mean defect size for the study population was 70.58 cm^2 (± 39.9 SD), with a minimum of 16 cm^2 and a maximum of 150 cm^2. Length and width of the defect were variable but had a range from 4x4 cm up to 15x10 cm. Flaps used for coverage and complications are shown in table 1. The color-coded duplex studies in this series resulted in documentation of a mean perforator diameter of 1.58 mm ± 0.4 mm with a minimum of 0.7 mm and a maximum of 2.4 mm. The mean PSV of the perforators was 33.37 cm/sec ± 18.8 SD with a minimum of 5 cm/sec and a maximum of 90 cm/sec. The main source vessel on the other hand had a mean diameter of 2.51 mm and PSV of 51.25cm/sec. The plot depicted in figure 3 shows the relationship between the viable post- operative flap surface area and the diameter and PSV of its perforator. There is no clear linear relation between both variables separately and the surviving part of the flap (no statistical significance). The maximal proposed flap surface areas based on the equation created was statistically plotted against the diameter and PSV of each perforator. Both relations show a statistical significance (P= <0.001) (figures 3 and 4). Figures 5 and 6 show representative cases from our study population. The idea for this study was generated from this same observation that some perforator flaps at our institution suffered from vascular compromise, although being theoretically within the confinements of the angiosome territory of the main vessel or the suggested perforasome of the perforator flap.

With the comprehensive review of literature presented in this work there was no direct link encountered between the characteristics of a perforator on which a flap is based and the possible dimensions for this specific flap. This study represents the first attempt to *mathematically* correlate the maximum size of a perforator flap to the unique characteristics of a specific perforator in lower limb reconstruction by generating a reproducible equation with easy to obtain variables that can be used pre-operatively to accurately predict the maximum surface area of the perforator flap. The trial of individualizing this correlation rather than generalizing the maximum dimensions of a perforator flap, as usually done in literature, is much needed in order to decrease complications. This work tries to augment the perforasome theory with hemodynamic principles to achieve a more dynamic and evolving understanding of the cutaneous microcirculation and thus achieving the best possible outcome in perforator flap surgery. Although the inclusion criteria for this study was extended to include the whole lower limb, most of the defects were seen in the leg and foot, more specifically the distal 2/3 of the leg and the heel. Anatomically, these locations have the least padding of soft tissue on bone and are very commonly subjected to open fractures resulting in complex raw areas indicated for flap coverage. The thigh and to a lesser extent the proximal leg have a larger muscle bulk with much less bone being directly subcutaneous [16]. In these cases, if coverage is needed, flaps and specifically perforator flaps come at a very low level of the reconstructive ladder/elevator. Being a workhorse flap for reconstruction of distal leg, ankle and heel defects, the reversed sural artery flap had the lion’s share in representation [21]. One could argue however, that the reversed sural flap is not a single perforator flap and has reversed flow and its vascularity, especially the venous drainage, has many theories with none of them proven to be the absolute one, and thus, could result in inaccurate results. Our technique uses the most distal of the peroneal perforators (3-5 cm above the lateral malleolus) (mapped preoperatively by duplex ultrasound) and thus sacrifices all the other septocutaneous peroneal perforators basing the flap solely on the pre-operatively identified one. The neuro- and venocutaneous arterial contribution to this flap is vital, yet also depends on reversed flow from the preserved perforator, thus just adding to its connections and not depending on another source of supply. The idea of reversed flow by itself should not cause false results because irrespective where the blood flow originates, the hemodynamics of the microcirculation remains the same. Other flaps used were based on a single perforator and thus served as proper representations of the perforasome except the sole anteromedial thigh flap used in this study. Due to the need of a very large flap, two perforators were used as pedicles for this flap during elevation, however a post-operative hematoma resulted in thrombosis of the distal perforator discovered during re-exploration, and thus the remaining flap size after debridement was used as a representative for the perforasome of the proximal perforator. The measurements provided by the CCD showed a mean perforator diameter of 1.58 mm ± 0.4 mm SD, with a mean PSV of 33.37cm/sec ± 18.81 cm/sec. These results were comparable to other published results in literature.

Kehrer et al reported a mean perforator diameter of 1.65 mm ± 0.45 mm measured by CCD with a mean PSV of 17.02 ± 6.74 cm/s. the discrepancy between the PSV can be explained by the fact that Kehrer measured the perforators of the SCIP and ALT flaps only which are more proximal than the ones used in this study [22]. On the other hand, Dusseldorp and Pennington reported a mean PSV of 27.5 cm/sec with a minimum of 4 cm/sec and a maximum of 72.9 cm/sec [13]. As per literature review, the normal PSV of peripheral lower limb arteries is 45-180c/sec [23]. However, these measurements are not static. They are affected by diameter of the vessel, location of the vessel in relation to the body, degree of possible stenosis if present, the accuracy of the CCD itself, and diameter of the parent vessel. This study establishes a direct statistically significant relationship between the diameters and PSVs of both main vessel and its perforator. In this series 57% of cases had a smooth post-operative course with no reported complications. Most complications were minor except in four cases. The first one was the anteromedial thigh flap were much of the flap surface area was lost due to ischemia as a result of a post-operative hematoma compressing one of the two perforator pedicles. The patient was promptly re-explored, hemostasis was achieved and the flap monitored until a line demarcation was present at which point it was debrided and replaced with a split thickness skin graft. Another major complication was in a patient who had underwent a reversed sural flap for a traumatic defect distal to the medial malleolus. The flap design was probably larger than the territory of the perforator leading to a large area of congestion and subsequent gangrene, which was further complicated by infection turning it into spreading moist gangrene. The necrotic part of the flap was eventually debrided and left at the donor site. The last two major complications were posterior tibial propeller flaps that were completely lost and thus just added to the total number of study subjects, yet excluded from the statistical analysis. In order to achieve the required correlation between maximal possible flap surface area and the diameter and PSV of the selected perforator, the raw data obtained through this series was analyzed in order to determine a possible mathematical relation. By comparing the postoperative remaining flap surface areas to the diameter and PSV of the specific perforator for each flap and using π as the correlation coefficient, the neo-equation was proposed. π was used as a constant based on our observation from the raw data collected, which led to a logical correlation between variables. Leung et al described an equation to calculate the DIEP perforasome for each perforator in the medial and lateral rows. His data were collected using CT angiography measuring both height and width of each perforsasome area in cms. To establish this mathematical relationship, they also used π as the correlation coefficient [12]. Our proposed neo-equation was used to calculate the proposed maximum flap dimensions for each of the 24 surviving flaps in this study. In order to validate this equation, the results were statistically analyzed and plotted against the diameters and PSVs of the perforators. In both cases the results were statistically significant entailing the proven mathematical correlation between these variables. When comparing the proposed maximal surface area with the actual remaining flap surface areas post-operatively, the patients could be groups into three categories:

- Patients having a linear association between the calculated flap dimensions according to the proposed equation and the actual flap dimensions used. This group represents the target goal of this study. This group represented 15 out of the 24 study subjects, a percentage of 62.5%. An example is a 35-years old male suffering from a traumatic defect of the middle 1/3 of the leg. A peroneal artery perforator flap was designed on a perforator having a diameter of 1.9 mm and a PSV of 42 cm/sec. a flap with the surface area of 240 cm^2. The patient had an uneventful postoperative period. When using the proposed equation, the maximal surface area of a flap based on this perforator would have been 250 cm^2.
- The second group of patients had an inverse linear association with underestimation of actual flap dimensions as compared to the calculated flap dimensions. This group was represented in 6 out of 24 individuals with a percentage of 25%. (Patients 16, 18, 19, 20 and 24). At first this group seems like the exact contradiction of the purpose of the equation. An example of this group is a 7-years old female suffering from a post traumatic defect around the medial malleolus. A reversed sural flap was designed and elevated on a perforator with a diameter of 1.2 mm and a PSV of 36 cm/sec. The perforator was located 4 cm above the lateral malleolus. The flap designed and elevated had a surface area of 165 cm^2. Using these parameters for calculating the proposed maximal flap surface area that could have been used it turned out to be 135 cm^2: less than the flap already used. This finding can be explained by the following:

3.1. Underestimation of the diameter of the perforator

CCDU is an operator dependent study. With excellent and expert hands there could still be discrepancies in measurement of the perforator diameter, as some may measure the external or internal diameter of the perforator with or without its coverings and fascia. Overestimation of the diameter of the perforator will result in overestimation of the proposed maximum surface area of the flap and vice versa.

3.2. Humoral and neural factors affecting the perforator diameter

Hemodynamics, by definition, is not a static field. Blood flow especially through the microvascular circulation is constantly affected and regulated by many factors, such as blood viscosity, peripheral resistance, sympathetic tone, local hypoxia and vasospasm/dilatation among others. All these factors lead to both increased and decreased flow that alters the PSV and the vessel diameter. The Duplex gives us a static measurement of these hemodynamic variables irrespective of the local state, which could be and usually is changed during the time of flap elevation, thus resulting in changes in the results of the equation.

3.3. Temperature

Wang et al., in 2017 performed an experimental study on multiple territory perforator flaps in order to determine the reasons for possible necrosis occurring at the distal parts of flaps that should be still within the adjacent choke vessel territories. Part of their observations was the effect of temperature on flaps: cutaneous blood flow, according to Wang, is not mainly for nutrition of the skin but for temperature regulation, with the sympathetic vascoactive tone being the most important regulator pf such mechanism. Under hyperthermic conditions skin blood is increased in order to increase sweating and temperature loss mechanism, thus incidentally increasing the cutaneous blood supply. Intra- and post-operative hypothermia will cause the opposite effects leading to decreased cutaneous blood supply predisposing to flap necrosis and loss despite being theoretically and functionally in the perforator territory [24].

3.4. Volume versus surface area

This equation and the measurements in this study were aiming at calculating the surface area of the flap that could have been used. According to the angiosome theory, this is not entirely accurate and thus presents as a limitation to this study [25]. The angiosome theory is based on the observation that a source vessel supplies a three-dimensional block of tissue composed of a length, width and thickness. By neglecting the thickness of the flap in this equation and focusing on the surface area and not the volume the results can be slightly inaccurate. For example, an obese individual will have a thicker subcutaneous tissue layer that would present as additional burden to be supplied by the perforator. Thus, logically the same perforator in a thin individual could theoretically supply a larger flap surface area due to decreased subcutaneous thickness. This same surface area taken in an obese individual should result in skin necrosis

3.5. Age

Within the 5 patients in this group B, 3 were children under the age of 10 (7, 9 and 4). The PSVs of this pediatric age group has been observed to be unusually small. There is no literature evidence about the correlation between age and PSV of a cutaneous perforator, but if this observation is not a coincidence, then a further more intense study into the validity of this equation with the pediatric age group is warranted. Group C had an inverse linear association with overestimation of actual flap dimensions as compared to the calculated flap dimensions. This group was composed of 3 out of 24 study individuals with a percentage of 12.5%. (study subjects 8, 12 and 14) The reasons for this result could be attributed to the same factors discussed before with group B. An example for this group is an 18-years old male with a raw area of the distal leg after a RTA. The defect after debridement was 49 cm^2. A reversed sural flap with a surface area of 91 cm^2 was elevated and inset into the defect. The calculated maximum surface area of this particular flap was 123 cm^2. Although being theoretically within the calculated safe zone, the flap suffered from partial loss with a remaining surviving flap surface area of 70 cm^2. Similar studies have been published but not resulting into a mathematical solution to this question. Yasir et al published in 2019 trying to answer the same question as regards lower limb perforator flaps. Their conclusions were based mainly on the proportions of the "safe" flap in relation to the leg. They concluded that *"up to one third of length of the segment of lower limb can be the safe length of the flap and up to one third of circumference of the segment of lower limb can be the safe breadth of the perforator/propeller flap"* [26]. The second study with a similar idea of quantifying blood flow through a flap to ensure the viability was the previously mentioned flap viability index study conducted by Pennington in 2012. This formula used the weight of the free DIEP flap as the reference "volume" to ensure whether the perforator(s) are enough to establish enough flow or not.

$$FVI = d1^4+d2^4+d3^4.....etc\ w$$

In this formula FVI stands for the flap viability index, d1 and d2 stand for the internal diameter of the perforator in millimeters, which was measured pre-operatively by CT angiography and W stands for the weight of the flap in kilograms [27]. This formula and the conclusions drawn by Pennington and his team were validated by Dusseldorp and colleagues in 2014 proving on the DIEP flap that a FVI less than 10 has a very high risk of skin and or fat necrosis, while a number more than 20 means that this flap should be relatively safe from both complications. Numbers between 10 and 20 indicate that a flap is unlikely to result in these setbacks [13]. This study, however, is not without limitations. The biggest limiting factor in our opinion is the study sample size in correlation with the types of flaps used. The sample size may not be mathematically sufficient to validate a proposed neo- equation given the fact that some flaps were used only once or twice, an unavoidable fact due to the specific needs and location of the presenting raw areas. As a result, we recommend starting a larger study aimed at three things:

1. Using the proposed neo-equation as a guide to plan the perforator flaps while providing more validation to it at the same time.
2. Modifying it to possibly include the thickness of the flap with the length and width in order to adhere more closely to the perforasome theory.
3. Unifying the study sample with respect to age group and type of flap recruited.
4. Using the equation in the planning of future studies and validating it through survival analyses.

Table 1: Showing counts and complications of the used flaps for coverage.

		Count	%
flap used	**sural artery propellar flap**	1	3.8%
	reversed sural flap	13	50%
	Posterior tibial perforator flap	6	23%
	Peroneal artery perforator flap	2	7.6%
	keystone flap	3	11.4%
	anteromedial thigh flap	1	3.8%
complications	**distal necrosis**	3	11.4%
	Partial flap necrosis	2	7.6%
	minor dehiscence	2	7.6%
	partial venous gangrene	1	3.8%
	recipient site infection	1	3.8%
	Complete flap necrosis	2	7.6%
	none	15	57%

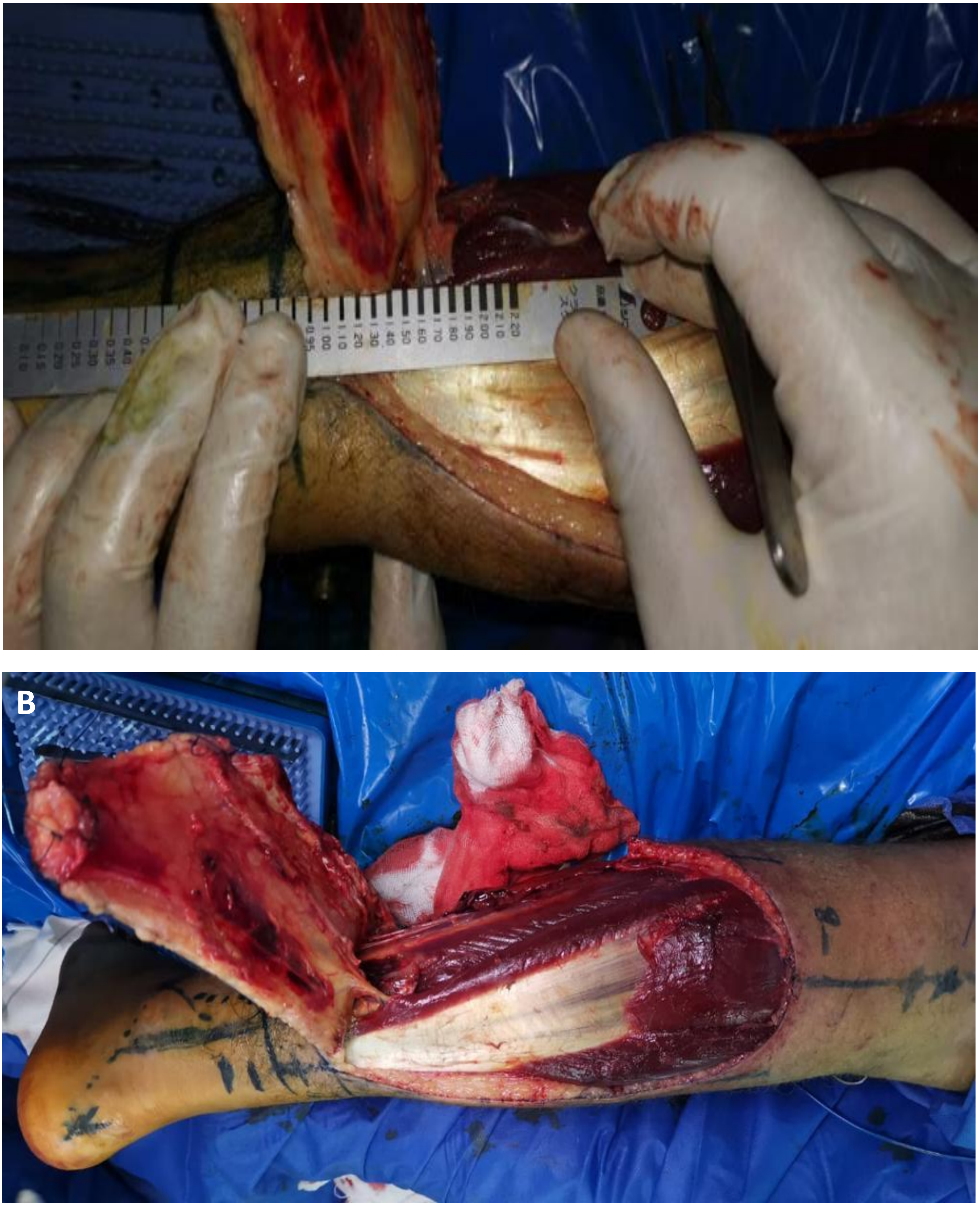


Figure 1: (A) Confirming the diameter of the perforator using the special ruler. (B) Subfascial elevation of the flap.

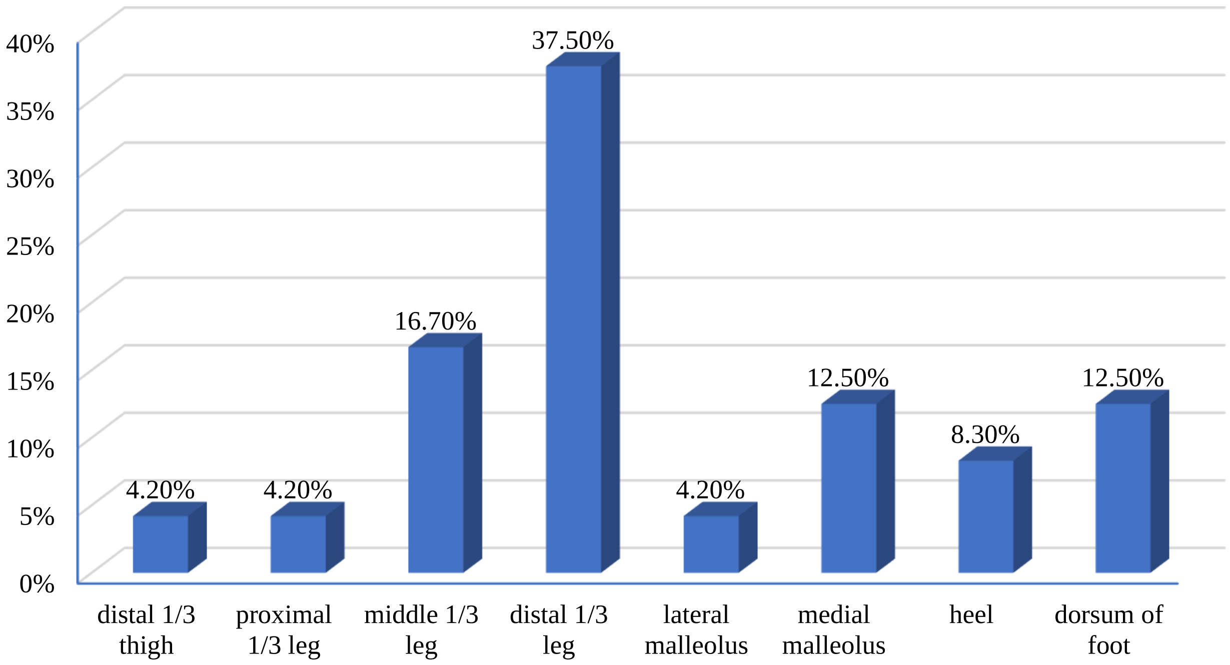


Figure 2: Bar chart showing the percentages of the different sites of skin defects in the study population.

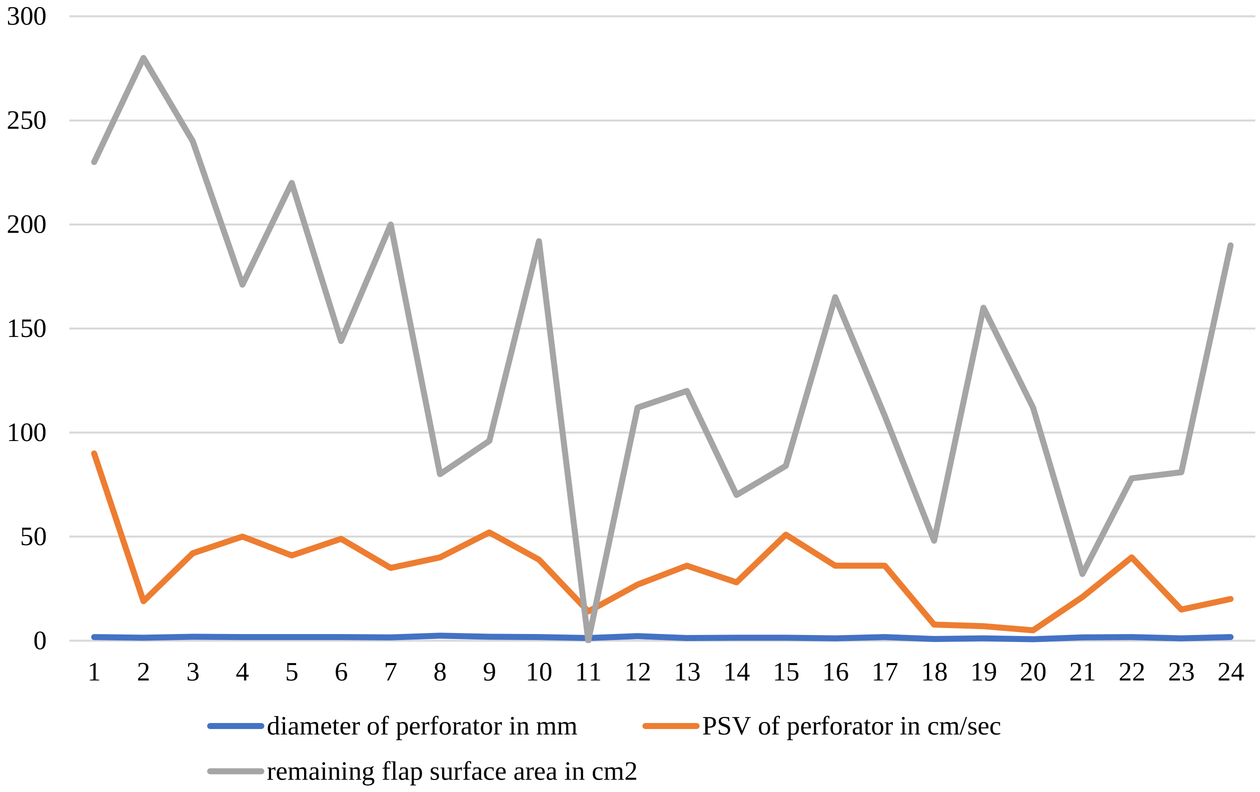


Figure 3: Line chart showing the relation between diameter and PSV of the perforator and the remaining flap surface area.

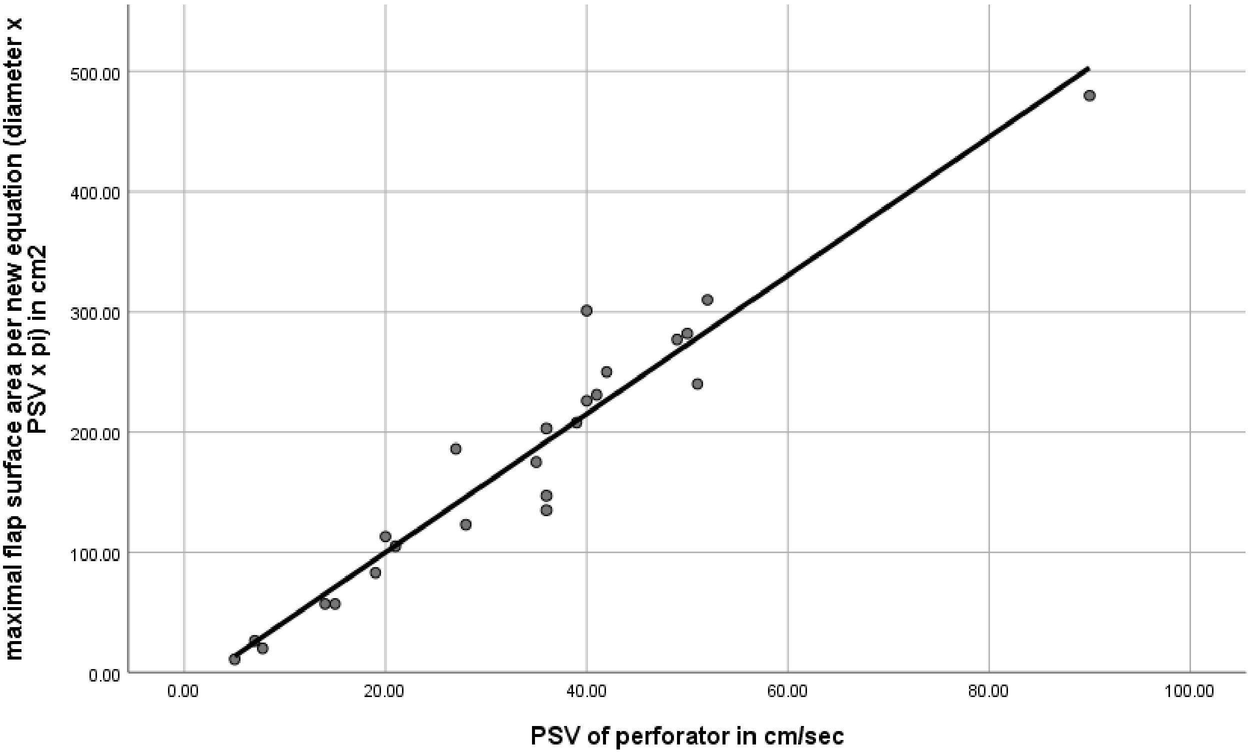


Figure 4: Line chart showing the linear ascending relationship between PSV of the perforator and the maximum proposed flap surface area.

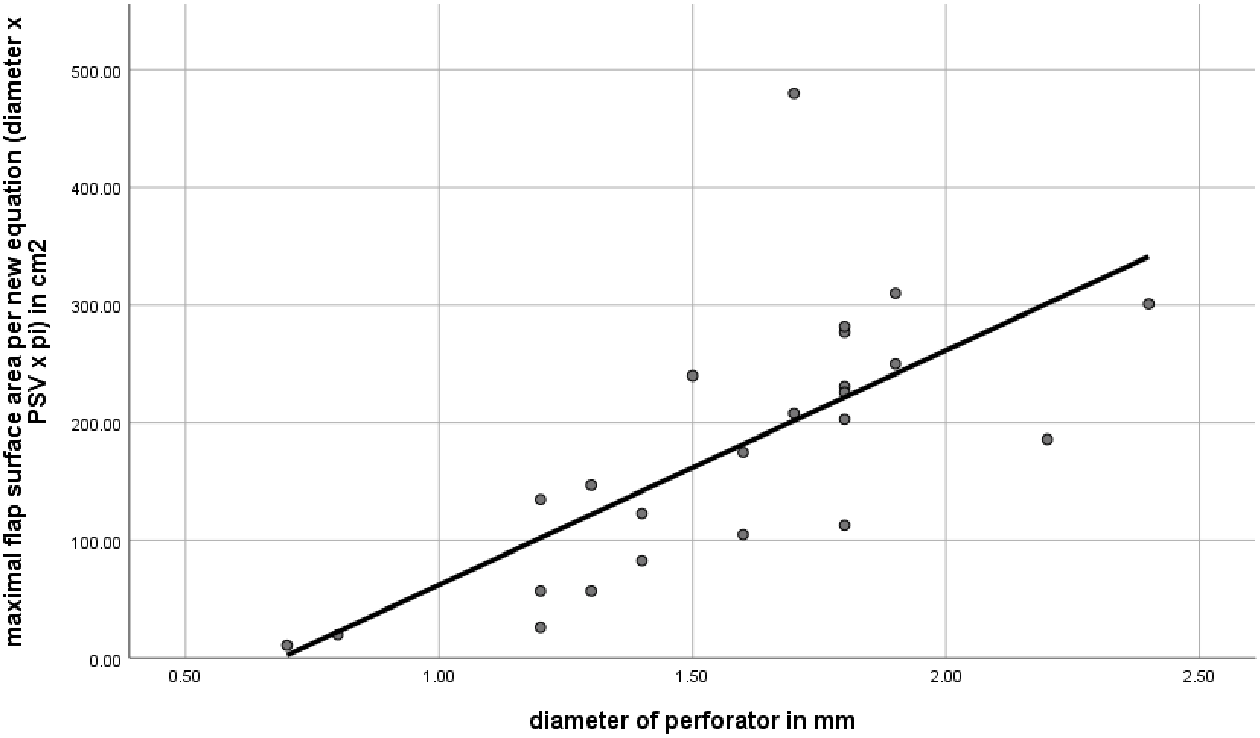


Figure 5: Line chart showing the linear ascending relationship between diameter of the perforator and the maximum proposed flap surface area.

Figure 6: 28-years-old male presented to our ER after a gunshot to the distal leg. After exclusion of other conditions and injuries and serial debridements, the resultant raw area was 11x9 cm with exposure with loss of part of the distal tibia. The decision was taken to cover it using a posterior tibial perforator propeller flap. CCDU revealed a suitable perforator having a diameter of 2.2 mm and a PSV of 27 cm/sec located 20 cm above the medial malleolus. Upon exploration of the perforator, it was found to be a musculocutanous perforator originating from the sural artery. The design of the flap was altered slightly to accommodate the new axis of the main vessel, but the planned flap dimensions were not changed. The flap was designed having dimensions of 17x7 cm and a surface area of 153 cm. the flap was rotated nearly 180° into the defect. Post-operatively there was partial loss of the flap resulting in a surviving area of 112 cm. after calculation of the proposed maximum flap surface area for the perforator it was found to be 186 cm, thus putting the observed results of this patient of the equation range.

Figure 7: 35 years old male fee medical history presenting post road traffic accident, complicated with osteomyelitis of the tibia resulting in a defect measuring 12x6 cm. peroneal perforator flap was summoned to cover the post sequestrectomy defect with the dimensions of 20 x 12 cm and a total surface area of $240cm^2$. The perforator used was 1.9 cm in diameter and had a peak systolic velocity of 42 cm/s. according to the neo-equation this perforator could safely carry a flap of $250cm^2$.

4. Conclusions

The preliminary equation allows predicting the flap surface area that can be safely carried on a particular perforator based on the peak Systolic Velocity and the perforator diameter.

References

[1] I. Koshima, S. Soeda. (1989). Inferior epigastric artery skin flaps without rectus abdominis muscle. British journal of plastic surgery. 42 (6): 645-648.

[2] U. Abdelfattah, H. A. Power, S. Song, K. Min, H. P. Suh, J. P. Hong. (2019). Algorithm for free perforator flap selection in lower extremity reconstruction based on 563 cases. Plastic and reconstructive surgery. 144 (5): 1202-1213.

[3] S. Soumian, R. Parmeshwar, M. Chandarana, S. Marla, S. Narayanan, G. Shetty. (2020). Chest wall perforator flaps for partial breast reconstruction: Surgical outcomes from a multicenter study. Archives of Plastic Surgery. 47 (02): 153-159.

[4] H. Chim, D. S. Nichols, M. Chopan. (2023). Ultrasound for Perforator Mapping and Flap Design in the Hand and Upper Extremity. The Journal of Hand Surgery.

[5] L. Wang, C. Y. Ma, Y. Shen, J. Fang, T. W. Haugen, B. Guo, J. Sun. (2021). Transverse cervical artery anterior perforator flap for head and neck oncological reconstruction: Preliminary study. Head & Neck. 43 (11): 3598-3607.

[6] W. Zhang, X. Li, X. Li. (2021). A systematic review and meta-analysis of perforator flaps in plantar defects: Risk analysis of complications. International Wound Journal. 18 (4): 525-535.

[7] Y. Qian, G. Li, H. Zang, S. Cao, Y. Liu, K. Yang, L. Mu. (2018). A systematic review and meta-analysis of free-style flaps: risk analysis of complications. Plastic and Reconstructive Surgery Global Open. 6 (2).

[8] G. I. Taylor, J. H. Palmer. (1987). The vascular territories (angiosomes) of the body: experimental study and clinical applications. British journal of plastic surgery. 40 (2): 113-141.

[9] M. Saint-Cyr, C. Wong, M. Schaverien, A. Mojallal, R. J. Rohrich. (2009). The perforasome theory: vascular anatomy and clinical implications. Plastic and reconstructive surgery. 124 (5): 1529-1544.

[10] F. Bekara, C. Herlin, A. Mojallal, R. Sinna, B. Ayestaray, F. Letois, B. Chaput. (2016). A systematic review and meta-analysis of perforator-pedicled propeller flaps in lower extremity defects: identification of risk factors for complications. Plastic and reconstructive surgery. 137 (1): 314-331.

[11] B. Chaput, N. Bertheuil, J. L. Grolleau, F. Bekara, R. Carloni, J. Laloze, C. Herlin. (2018).

Comparison of propeller perforator flap and venous supercharged propeller perforator flap in reconstruction of lower limb soft tissue defect: a prospective study. Microsurgery. 38 (2): 177-184.

[12] R. Leung, M. P. Chae, V. Tobin, D. J. Hunter-Smith, W. M. Rozen. (2018). In-vivo quantitative mapping of the perforasomes of deep inferior epigastric artery perforators. Plastic and Reconstructive Surgery Global Open. 6 (10).

[13] J. R. Dusseldorp, D. G. Pennington. (2014). Quantifying blood flow in the DIEP flap: an ultrasonographic study. Plastic and Reconstructive Surgery Global Open. 2 (10).

[14] R. E. Giunta, A. Geisweid, A. M. Feller. (2000). The value of preoperative Doppler sonography for planning free perforator flaps. Plastic and reconstructive surgery. 105 (7): 2381-2386.

[15] P. N. Blondeel, S. F. Morris, G. G. Hallock, P. C. Neligan. (2013). Perforator flaps: anatomy, technique, & clinical applications. CRC press.

[16] G. G. Hallock. (2003). Doppler sonography and color duplex imaging for planning a perforator flap. Clinics in plastic surgery. 30 (3): 347-357.

[17] S. Standring. (2021). Gray's anatomy e-book: the anatomical basis of clinical practice. Elsevier Health Sciences.

[18] U. Abdelfattah, H. A. Power, S. Song, K. Min, H. P. Suh, J. P. Hong. (2019). Algorithm for free perforator flap selection in lower extremity reconstruction based on 563 cases. Plastic and reconstructive surgery. 144 (5): 1202-1213.

[19] Y. H. Chan. (2003). Biostatistics 102: quantitative data–parametric & non-parametric tests. Blood Press. 140 (24.08): 79.

[20] Y. H. Chan. (2003). Biostatistics 103: qualitative data-tests of independence. Singapore Med J. 44 (10): 498-503.

[21] A. M. Afifi, T. A. Mahboub, J. E. Losee, D. M. Smith, H. H. Khalil. (2008). The reverse sural flap: modifications to improve efficacy in foot and ankle reconstruction. Annals of plastic surgery. 61 (4): 430-436.

[22] A. Kehrer, P. I. Heidekrueger, D. Lonic, C. D. Taeger, S. Klein, P. Lamby, N. P. Batista da Silva. (2020). High-resolution ultrasound-guided perforator mapping and characterization by the microsurgeon in lower limb reconstruction. Journal of reconstructive microsurgery. 37 (01): 075-082.

[23] P. Gupta, S. Lyons, S. Hedgire. (2019). Ultrasound imaging of the arterial system. Cardiovascular Diagnosis and Therapy. 9 (Suppl 1): S2.

[24] L. Wang, Z. W. Zhou, L. H. Yang, X. Y. Tao, X. L. Feng, J. Ding, W. Y. Gao. (2017). Vasculature characterization of a multiterritory perforator flap: an experimental study. Journal of reconstructive microsurgery. 33 (04): 292-297.

[25] G. I. Taylor. (2003). The angiosomes of the body and their supply to perforator flaps. Clinics in plastic surgery. 30 (3): 331-342.

[26] M. Yasir, A. H. Wani, H. R. Zargar. (2017). Perforator flaps for reconstruction of lower limb defects. World journal of plastic surgery. 6 (1): 74.

[27] D. G. Pennington, P. Rome, P. Kitchener. (2012). Predicting results of DIEP flap reconstruction: the flap viability index. Journal of plastic, reconstructive & aesthetic surgery. 65 (11): 1490-1495.