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Soft Tissue Reconstruction Around the Ankle with Peroneal and Posterior Tibial Artery Perforator Flaps: A Randomized Controlled Trial

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ABSTRACT

Background: Soft tissue defects of the ankle region continue to present a complex reconstructive challenge to the reconstructive surgeon. Many flaps have been used to rebuild these defects, and each flap has its own merits and drawbacks. This randomized controlled study was designed to compare between the peroneal artery perforator flap and the posterior tibial artery perforator flap for the ankle region reconstruction and finding out advantages and disadvantages of each flap.

Methods: Between July 2020 and April 2022, 22 patients presented with soft tissue defects around the ankle with exposed vital structures as bones and tendons, who were categorized into two equal groups group 1: The peroneal artery perforator flap group (11 patients) and group 2: The posterior tibial artery perforator flap group (11 patients). Post-operative complications were the primary comparative parameters.

Results: In total 22 patients with tissue defects around the ankle region were operated with either the peroneal artery perforator flap and the posterior tibial artery perforator flap 11 cases in each group, the post-operative flap complications as total flap loss and distal flap necrosis were (18.2%), (27.3%) receptively in the peroneal group and (27.3%), (36.4%) in the posterior tibial group and the mean time of flap elevation was longer in the posterior tibial group (106.82min) compared to the peroneal group with (64.55min).

Conclusion: The peroneal artery perforator flap is better elevated as pedicled while the posterior tibial artery perforator flap better elevated as propeller.

Key Words: *Posterior tibial flap – Peroneal flap – Perforator flap – Ankle reconstruction.*

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INTRODUCTION

Soft tissue defects of the ankle region continue to be a difficult reconstructive problem. Many types of flaps, such as fasciocutaneous, muscle, perforator, and free flaps, have been used to reconstruct these defects, and each flap has its own advantages, disadvantages, and indications **[1]**.

Local fasciocutaneous flaps pose the disadvantages of limited availability and mobilization in the ankle region. Muscle flaps are utilized primarily in the coverage of the proximal leg defects and they have a constricted job in reconstruction of the distal leg soft tissue problems in addition to functional deficit sequelae. Free tissue transfer has been the primary solution to provide appropriate coverage of cutaneous defects particularly in the ankle region, but it is a time consuming process, needs microsurgical skills and associated resources **[2]**.

In 1983, "Donski and Fogdestam" introduced a fasciocutaneous flap using perforators of the peroneal artery surrounding the ankle and their connections with the superficial sural artery. This flap has been widely used for rebuilding of ankle and foot soft tissue defects **[3]**. "In 1986, "Amarante et al." first described a distally based fasciocutaneous" flap dependent on the perforators coming from the posterior tibial artery, and this flap has been also extensively utilized for soft tissue reconstruction around the ankle" **[4]**.

The aim of this study was to compare between the peroneal artery perforator flap and the posterior tibial artery perforator flap for the ankle region reconstruction and finding out advantages and disadvantages of each flap.

PATIENTS AND METHODS

This a prospective randomized controlled study "conducted at Mansoura University Hospital from" July 2020 to April 2022. The study was approved by our institutional review board (IRB code: MS.20.10.8) and registered in the pan African clinical trial registry (PACTR202205698668673). It included 22 patients presented with soft tissue defects of the ankle and distal to the ankle regions as post traumatic defects or chronic non healing ulcers with exposed vital structures as bones and tendons. The studied patients were divided into two equal groups using a simple random sampling way with sequentially numbered opaque sealed envelopes (SNOSE); group 1: The peroneal perforator flap group (11 patients) and group 2: The posterior tibial perforator flap group (11 patients). Post-operative complications were the primary outcome to study. Sample size was calculated using Select Statistical sample size calculator Considering alpha error 5%, beta error 20%, and assuming that post-operative complications developed in peroneal group was 57.1%, while post-operative complications developed in posterior tibial group was 8.3% **[5]**. Patients presented with injury in the lower leg with affected either posterior tibial perforators or peroneal perforators were excluded. Diabetic, smokers and patient with peripheral vascular diseases were also excluded.

Pre-operative assessment: Patient data were collected concerning time and mode of injury, previous procedures done dealing with the trauma if present and patient medical and surgical comorbidities. Patients weight, height and body mass index were calculated, Basic laboratory and radiological investigations were done. Pre-operative assessment of the defect was done regarding its site, size, depth, state of surrounding soft tissue and the condition of skin that will be the source of the flap. State of the venous and arterial circulation of the limb was assessed clinically and by Doppler study. The limbs with arterial or venous vascular compromise were excluded from the study. Assessment of the perforators of the posterior and peroneal arteries was done using a hand-held Doppler ultrasound scanner (8MHz) guided by the anatomical background of the normal sites of the distal perforators as follows, the posterior tibial artery perforators usually lie at 8-12cm above the medial malleolus (Fig. 1) and the peroneal artery perforators lie within 10 cm above the lateral malleolus (Fig. 2). The perforators heard by Doppler probe were marked by skin marker and the flap dimensions were determined according to defect size after planned refreshment and perforator site.

Surgical intervention: The procedure was done under general or spinal anaesthesia after giving the patient a prophylactic dose of the antibiotic ceftriaxone 1gm then a pneumatic tourniquet applied around the ipsilateral thigh after sterilization using 10% povidone iodine. The defect was prepared by excising any remnants of devitalized tissues and removing even doubtful tissues leaving only healthy vital clean normal bleeding tissues.

Incision was done along the marked flap design that extended through the deep fascia of the leg down to the level of sub-fascial plane to ensure that the suprafascial vascular plexus was incorporated within the flap (fasciocutaneous) for better vascular supply of the flap (Fig. 3). Subfascial dissection of the flap is done till we reach the marked perforators. After dissecting all of the perforators, their location in the flap, diameter, pulsatility after temporary release of torniquet, and existence of appropriate venae committantes were all assessed. The perforator that would allow a good advanced movement was meticulously dissected for (2-3cm) by teasing the muscle fibers gently. The perforator was then irrigated intermittently with 2% lidocaine solution to relieve any vascular spasm that could result from surgical manipulation during dissection. After completion of dissection, flap elevation was done first as pedicled if the flap was fit for covering the defect without pedicle twisting, while elevated as propeller in distant defects and if the pedicle was twisted. During flap elevation, fascia was stitched to the skin to minimize shearing or separation of the fascia from the skin to preserve suprafascial vascular plexus and ensure efficient blood supply to the flap. After flap elevation, the tourniquet was deflated to assess flap vascularity by evaluating the bleeding points of distal ends of the flap. Haemostasis was done by cauterization of the bleeding spots using bipolar diathermy. Flap elevation was proceeded until it was enough for the flap inset without any tension or twisting of the flap pedicle which may lead to obliteration of the feeding perforators and flap congestion or ischemia.

In 4 cases (3 cases in posterior tibial group and one case in peroneal group), flap delay was done. When we rotated the flap to cover the defect, the flap became congested. The flap was rotated back to its original site and left for 3 weeks, then moved to cover the defect again.

The donor site of the flap was closed by a split thickness skin graft (STSG) harvested from the thigh (Fig. 4). The donor "site was closed primary in" only one case. Light Dressing was applied with a window to allow flap monitoring and the leg was elevated in bed to decrease venous congestion.

Post-operative care: The flap was monitored by the following parameters: Temperature, colour, capillary refill, bleeding after dermal pin prick and flap firmness. Monitoring was started immediately post-operative and continued every 4 hours for two days, then once daily. The patients received regular dose of the antibiotic ceftriaxone 2mg every 24h for 14 days post-operative and prophylactic dose of low molecular weight heparin every 24h to avoid deep venous thrombosis.

Dressing over Split thickness skin grafts was removed on the fifth day post-operative. This was followed by repeated dressing every other day with sterile Vaseline gauze. The stitches and staples were removed after 10 days.

The starting time and the end time of flap elevation and inset were recorded. Time needed till patient mobilization was also calculated. The defect size was measured before and after debridement. The flap viability was assessed in relation to the defect site and the body mass index (BMI) of the patients.

The following ratings have been used to evaluate patient satisfaction as regard covering of the defect, cosmetic result of the flap and donor site morbidity on a five-point scale on a five-point scale: (1) unsatisfied, (2) slightly satisfied, (3) moderately satisfied, (4) quite satisfied, and (5) completely satisfied **[6]**.

RESULTS

Both groups of study were statistically homogenous regarding their demographic data and clinical presentation (Table 1). There was also no statistically significant difference between the studied groups as regard flap elevation type, flap size (width & length) and donor site, but the mean time of flap elevation and insetting was statistically significant higher in group II than group I (Table 2).

Concerning flap viability, re-operation and patient satisfaction score, results show no statistically significant difference between the studied groups (Table 3). No statistically significant relation between flap viability and the defect site or BMI has been found in both groups (Table 4).

The maximum flap length harvested without any complications as distal flap necrosis or total flap loss was 22cm in peroneal group (Fig. 5) and 16cm in posterior tibial group (Fig. 6).

Table (1): Demographic and clinical data of the studied groups.

	Group 1 (N=11)	Group 2 (N=11)	Test of significance
Age in years:			
Mean ± SD	31.36±17.52	30.09±15.14	*t*=0.182
Range	(10-60)	(12-55)	*p*=0.857
Sex:			
Male	9 (81.8%)	8 (72.7%)	$!^{2FET}$=0.259
Female	2 (18.2%)	3 (27.3%)	*p*=1.0
Height in cm:			
Mean ± SD	167.73±10.46	169.36±6.83	*t*=0.434
Range	(148-178)	(158-177)	*p*=0.669
Weight in kg:			
Mean ± SD	73.73±13.42	76.45±13.46	*t*=0.476
Range	(54-93)	(57-95)	*p*=0.639
BMI (Kg/m^2):			
Mean ± SD	26.06±3.34	26.61±4.25	*t*=0.339
Range	(21.9-33.12)	(20.04-33.65)	*p*=0.738
Cause:			
Post-traumatic	7 (63.6%)	8 (72.7%)	$!^{2FET}$=0.210
Chronic ulcer	4 (36.4%)	3 (27.3%)	*p*=1.0
Site:			
Distal to ankle	4 (36.4%)	6 (54.5%)	$!^{2FET}$=0.733
Ankle	7 (63.6%)	5 (45.5%)	*p*=0.392
Defect width before debridement:			
Mean ± SD	4.41±1.51	4.0±0.59	*t*=0.835
Range	(2.5-8)	(3-5)	*p*=0.414
Defect width after debridement:			
Mean ± SD	6.23±1.42	5.59±0.86	*t*=1.27
Range	(5-9)	(4-7)	*p*=0.218
Defect length before debridement:			
Mean ± SD	5.36±1.45	4.59±0.70	*t*=1.59
Range	(4-8)	(3.5-6)	*p*=0.127
Defect length after treatment:			
Mean ± SD	5.18±1.40	4.73±0.56	*t*=0.998
Range	(4-8)	(4-6)	*p*=0.330

N: Number of cases. $!^{2FET}$: Fischer exact test.
t : Student *t*-test. *p*: Probability.

Table (2): Operative details of the studied groups.

	Group 1 (N=11)	Group 2 (N=11)	Test of significance
Type of Flap elevation:			
Pedicled	7 (63.6%)	3 (27.3%)	!2FET=2.93
Propeller	4 (36.4%)	8 (72.7%)	*p*=0.087
Flap width in cm:			
Mean ± SD	5.55±1.21	5.32±0.68	*t*=0.542
Range	(4-8)	(4-6.5)	*p*=0.594
Flap length in cm:			
Mean ± SD	17.45±3.91	17.91±4.01	*t*=0.269
Range	(10-24)	(10-25)	*p*=0.791
Time of flap elevation & insetting in minutes:			
Mean ± SD	64.55±37.78	106.82±35.52	z=2.70
Range	(30-130)	(45-140)	*p*=0.014*
Donor site:			
Primary closure	1 (9.1%)	0	!2FET=1.05
STSG	10 (90.9%)	11(100%)	*p*=0.306

N: Number of cases. !2FET: Fischer exact test.
z : Mann Whitney U test. *p*: Probability.
* Statistically significant.

Table (3): Final outcome of the studied groups.

	Group 1 (N=11)	Group 2 (N=11)	Test of significance
Viability:			
Total flap survives	6 (54.5%)	4 (36.4%)	!2MC=0.743
Total flap loss	2 (18.2%)	3 (27.3%)	*p*=0.690
Distal flap necrosis	3 (27.3%)	4 (36.4%)	
Period of immobilization in days:			
Mean ± SD	26±7.76	26.18±8.18	*t*=0.053
Range	(15-35)	(14-38)	*p*=0.958
Score of Patient satisfaction:			
Mean ± SD	3.82±1.078	3.18±1.08	*t*=1.38
Range	(2-5)	(2-5)	*p*=0.182
Reoperation:			
No	2 (18.2%)	4 (36.4%)	!2FET=0.917
Yes	9 (81.8%)	7 (63.6%)	*p*=0.338

N: Number of cases. *p*: Probability.
t : Student *t*-test. *Statistically significant.
!2MC: Monte Carlo test. !2FET: Fischer exact test.

Table (4): Relation between Viability, defect site and body mass index of the studied groups.

	Viability	Defect site		Test of significance	BMI (kg/m2)	Test of significance
		Distal to ankle N (%)	Ankle N (%)			
Group 1	Total flap loss	1 (33.3%)	1 (50%)	FET	27.27±1.52	*t*=.598
	Distal flap necrosis	2 (66.7%)	1 (50%)	*p*=1.0	25.19±4.53	*p*=0.592
Group 2	Total flap loss	3 (60%)	0 (0.0%)	FET	28.31±7.26	*t*=0.394
	Distal flap necrosis	2 (40%)	2 (100%)	*p*=0.429	26.73±3.29	*p*=0.710

N: Number of cases. FET: Fischer exact test. *p*: Probability. *t*: Student *t*-test.

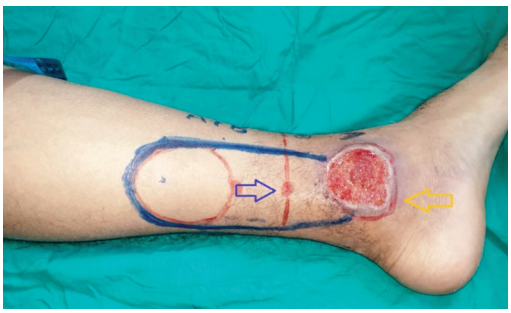

Fig. (1): Shows marking of the posterior tibial artery perforators guided by handheld Doppler, blue arrow refers to the perforator and yellow arrow for medial malleolus, the distance was 6cm.

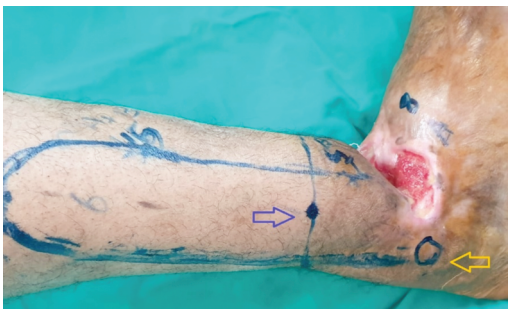

Fig. (2): Shows identification of the peronral artery perforators, blue arrow refers to the perforator and yellow arrow for lateral malleolus, the distance was 7cm.

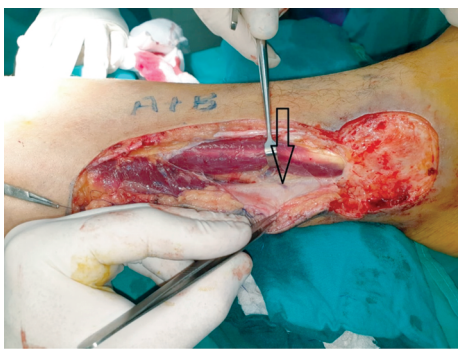

Fig. (3): Shows Subfascial dissection of the flap and identification of the perforator, black arrow refers to the perforator.

Fig. (4): Shows the flap inset and the donor site closure with split thickness skin graft.

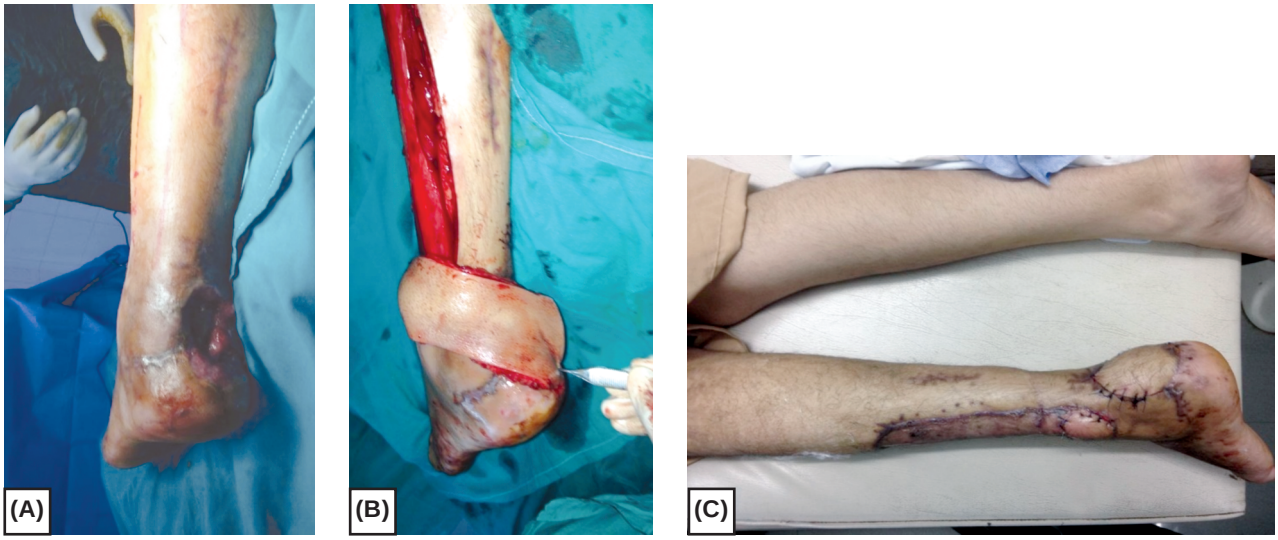

Fig. (5): A 22-year-old male patient with chronic non healing ulcer on back of left ankle (A). Pedicled peroneal artery perforator flap elevation with leaving a skin bridge between the donor site and the defect (B). Separation of the flap with healing of the flap after 3 weeks (C).

Fig. (6): A 28-year-old male patient with chronic ulcer on left medial malleolus (A). Visualization of the posterior tibial artery perforator (B). Elevation of the propeller posterior tibial artery perforator flap (C). The flap inset to cover the defect (D). Complete healing of the flap after 30 days (E).

DISCUSSION

Many studies have been reported in the literature to evaluate the efficacy of various types of flaps in reconstruction of soft tissue defects around the ankle **[7]**. Our current clinical trial was conducted to compare the two commonest types of flaps used for reconstruction of the defects around the ankle, namely the peroneal and posterior tibail artery perforator flaps. In our study, we excluded patient who were smokers as smoking affect perforator blood supply and is associated with flap complications as reported by Saint-Cyr et al., in his study about pedicled perforator flaps **[8]**, patients with comorbidities as diabetes mellitus and peripheral vascular diseases were also excluded because they were at higher incidence of limb ischaemia. limited tissue perfusion may be a result of damage in the macrocirculation or microcirculation. Diabetic patients are more prone to dangerous infections, rendering the healing of wounds more problematic and this also was reported by Zhang et al., in his study on perforator flaps **[9]**.

In our study, the age of our patients ranged from 10-60 years in the peroneal group and 12-55 years in the posterior tibial group, and males were more affected than females. In a study done by Dong, et al for lower limb reconstruction, they reported that the age of the patients extended from 12-73 years and males were also more affected **[10]**. In another study done by Demiri et al., for distal lower limb and foot reconstruction, the age of the patients ranged from 20-83 years, and males were also more affected **[11]**.

Regarding the cause of the leg defects in our study, the majority of cases were post traumatic due to road traffic accidents (RTA) and the remaining were due to chronic ulcer. The cause of leg defects in a study by Tharayil and Patil for lower third leg, ankle and foot reconstruction was mainly car accidents **[12]**. And the majority of cases in another study by Dong et al., using propeller and pedicled perforator flaps to cover leg defects, were due to road traffic accidents **[10]**.

So according to our study and the other reported studies for lower limb reconstruction, road traffic accidents (RTA) represent the most common cause of lower limb defects, and the other different causes of defects are less common compared to road traffic accidents.

The maximum flap length that elevated safely in our study without complications was 22cm in the peroneal flap group and 18cm in the posterior tibial flap group. In a study done by Cheng et al., on peroneal artery perforator flap for lower extremity reconstruction, the maximum flap length was 20cm **[13]**. Vaienti et al., in their study on posterior tibial artery perforator flap for rebuilding of Achilles region disorders, reported that the maximum flap length was 18cm **[14]**.

Moreover, Koshima et al., harvested a 19cm flap depends on only one perforator from the posterior tibial artery **[15]**. While Rad et al., introduced a flap size up to 22cm depending on one perforator also from the peroneal artery **[16]**. In our study, despite we harvested pedicled and propeller peroneal artery perforator flaps reaching up to 22 and 20cm, respectively without any complication, “the posterior tibial artery perforator flaps that exceeded 20cm showed distal flap necrosis.

In a study by Lu et al., about flexibility of the peroneal artery perforator flap for coverage of the tissue defects of the distal lower limb, they found that among the five types of peroneal artery flaps (propeller, pedicled, advancement, proximally based and distally based island flaps), the pedicled flaps were often the preferred due to the lower incidence of venous congestion **[17]**.

In our study, the pedicled peroneal artery perforator flaps were associated with less complications as total or distal flap necrosis compared to the propeller flaps while this was the opposite in the “posterior tibial artery perforator flap group” as the pedicled flap was more liable to twisting of the pedicle. This also was reported by Vaienti et al who reported that the propeller posterior tibial perforator flaps were the best option to resurface difficult soft-tissue disorders of the Achilles region” **[14]**.

In both groups of our study, flaps that were elevated propeller is more time consuming and technically difficult than flaps that were elevated as pedicled as reported by Wong et al., in their study about versatility of pedicled perforator flaps in lower limb reconstruction **[18]**.

In our study, there was no statistically significant relation between the body mass index and the flap viability in both groups. In a study done by Shayan et al., “about the impact of the body weight and subsequent weight reduction on the perforators, they found that “the perforators underwent a statistically significant, irreversible, and maintained dilatation as a consequence of the increased requirements of a broadened capillary bed,” produced in response to generalized gaining of the body weight. The weight loss that occurred before perforator flap surgery did not affect the diameter of

perforators, allowing better flap harvest and survival. In elective case, patients could be advised to reduce their body weight before the operation, with the confirmed advantage to operative outcomes from a reduced body mass index and the value of maintained perforator diameter for flap survival **[19]**.

In our study, flaps that were harvested to cover defects distant to the ankle were associated with flap complications and total flap loss as reported by Byluo et al., **[20]**. However, there was no statistically significant relation between defect site and flap viability in this study.

In a study done by Koh et al., about free compared to pedicled perforator flaps for lower limb reconstruction they found that pedicled perforator flaps were more reasonable, seeking simplicity and easy to be done while free flap need high learning curve and specialized centers **[21]**.

Also our study provided a simple solution for covering the tissue defects around ankle region with pedicled or propeller perforator flaps than the more complex free flaps.

Conclusion:

Soft tissue defects around ankle region are very challenging in reconstruction as there is limited options for local flaps. This was solved by perforator based flaps that provided tissue of the same locality and preserve the main vessels. Our study demonstrated a solution when either the peroneal artery perforator flaps and the posterior tibial artery perforator flaps are suitable for soft tissue reconstruction around ankle region.

The peroneal artery perforator flaps were better when elevated as pedicled flaps, and the posterior tibial artery perforator flaps were better when elevated as propeller flaps.

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REFERENCES

1- Luo Z., Lv G., Wei J., Ni J., Liu L., Peng P. and Dong Z.: Comparison between distally based peroneal and posterior tibial artery perforator-plus fasciocutaneous flap for reconstruction of the lower extremity. Burns, 46 (1): 225-33, 2020.

2- Hifny M.A., Tohamy A.M., Rabie O. and Ali A.A.: Propeller perforator flaps for coverage of soft tissue defects in the middle and distal lower extremities. In Annales de Chirurgie Plastique Esthétique, 65 (1): 54-60, 2020.

3- Donski P.K. and Fogdestam I.: Distally based fasciocutaneous flap from the sural region. Scandinavian Journal of Plastic and Reconstructive Surgery, 17 (3): 191-6, 1983.

4- Reis J. and Soares R.: A new distally based fasciocutaneous flap of the leg. British Journal of Plastic Surgery, 39 (3): 338-40, 1986.

5- Lese I., Grobbelaar A.O., Sabau D., Georgescu A.V., Constantinescu M.A. and Olariu R.: The Propeller Flap for Traumatic Distal Lower-Limb Reconstruction Journal of Bone and Joint Surgery, 00: 1-9, 2019.

6- Abdelshaheed M.E.: Classification and clinical evaluation of" spare parts" procedures in mutilating hand injuries. Hand Surgery and Rehabilitation, 40 (1): 75-80, 2021.

7- Ring A., Kirchhoff P., Goertz O., Behr B., Daigeler A., Lehnhardt M. and Harati K.: Reconstruction of soft-tissue defects at the foot and ankle after oncological resection. Frontiers in Surgery, 8 (3): 15, 2016.

8- Lecours C., Saint-Cyr M., Wong C., Bernier C., Mailhot E., Tardif M. and Chollet A.: Freestyle pedicle perforator flaps: Clinical results and vascular anatomy. Plastic and Reconstructive Surgery, 126 (5): 1589-603, 2010.

9- Zhang W., Li X. and Li X.: A systematic review and meta-analysis of perforator flaps in plantar defects: Risk analysis of complications. International Wound Journal, 4: 525-35, 2021.

10- Dong K.X., Xu Y.Q., Fan X.Y., Xu L.J., Su X.X., Long H., Xu L.Q. and He X.Q.: Perforator pedicled propeller flaps for soft tissue coverage of lower leg and foot defects. Orthopaedic Surgery, 6 (1): 42-6, 2014.

11- Demiri E., Foroglou P., Dionyssiou D., Antoniou A., Kakas P., Pavlidis L. and Lazaridis L.: Our experience with the lateral supramalleolar island flap for reconstruction of the distal leg and foot: a review of 20 cases. Scandinavian Journal of Plastic and Reconstructive Surgery and Hand Surgery, 40 (2): 106-10, 2006.

12- Tharayil J. and Patil R.K.: Reverse peroneal artery flap for large defects of ankle and foot: A reliable reconstructive technique. Indian Journal of Plastic Surgery, 45 (1): 45, 2012.

13- Cheng L., Yang X., Chen T. and Li Z.: Peroneal artery perforator flap for the treatment of chronic lower extremity wounds. Journal of Orthopaedic Surgery and Research, 12 (1): 1-7, 2017.

14- Vaienti L., Calori G.M., Leone F., Brioschi M., Parodi P.C. and Marchesi A.: Posterior tibial artery perforator flaps for coverage of Achilles region defects. Injury, 45 (1): 33-7, 2014.

15- Koshima I., Nanba Y., Tsutsui T., Takahashi Y. and Itoh S.: Perforator flaps in lower extremity reconstruction. Handchirurgie· Mikrochirurgie· Plastische Chirurgie., 34 (04): 251-6,2002.

16- Rad A.N., Singh N.K. and Rosson G.D.: Peroneal artery perforator-based propeller flap reconstruction of the lateral distal lower extremity after tumor extirpation: Case report and literature review. Microsurgery, 28 (8): 663-70, 2008.

17- Lu T.C., Lin C.H., Lin C.H., Lin Y.T., Chen R.F. and Wei F.C.: Versatility of the pedicled peroneal artery perforator

flaps for soft-tissue coverage of the lower leg and foot defects. Journal of Plastic, Reconstructive & Aesthetic Surgery, 64 (3): 386-93, 2011.

18- Wong J.K., Deek N., Hsu C.C., Chen H.Y., Lin C.H. and Lin C.H.: Versatility and "flap efficiency" of pedicled perforator flaps in lower extremity reconstruction. Journal of Plastic, Reconstructive & Aesthetic Surgery, 70 (1): 67-77, 2017.

19- Shayan R., Rozen W.M., Bernard S., Corlett R.J., Ashton M.W. and Taylor G.I.: Perforator dilatation induced by body weight gain is not reversed by subsequent weight loss: Implications for perforator flaps. Plastic and Reconstructive Surgery, 122 (6): 1765-72, 2008.

20- Luo Z., Lv G., Wei J., Ni J., Liu L., Peng P. and Dong Z.: Comparison between distally based peroneal and posterior tibial artery perforator-plus fasciocutaneous flap for reconstruction of the lower extremity. Burns, 46 (1): 225-33, 2020.

21- Koh K., Goh T.L., Song C.T., Suh H.S., Rovito P.V., Hong J.P. and Hallock G.G.: Free versus pedicled perforator flaps for lower extremity reconstruction: A multicenter comparison of institutional practices and outcomes. Journal of Reconstructive Microsurgery, 34 (08): 572-80, 2018.