

Evaluation of the Medial Sural Artery Perforator Flap for Validity Around Knee Reconstruction

Aly Shafei Rabei Aly^{1,*} M.B.B.Ch, Magdy AbdAlmoktader¹ MD. and Mohamed Osama Ouf¹ MD.

** Corresponding Author:*

Aly Shafei Rabei Aly
shafali783@gmail.com

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¹Department of Plastic Surgery and Burn, Faculty of Medicine, Al-Azhar University, Cairo, Egypt.

ABSTRACT

Background: peri-knee Soft tissue defects are often caused by trauma, post-burn contracted scars, and a wide excision of malignancy. These defects signify a great challenge to surgeons when faced with reconstructive surgery.

Aim of the study: Evaluation of the versatility of pedicle medial sural artery perforator flap as a regional flap in reconstruction of knee and around knee soft tissue defects.

Patients and Methods: Twenty patients were recruited in this study who suffered soft tissue defects of knee and peri-knee with exposed vital structures (patellar tendon, bone, nerve, joint, exposed implant, infection, and burn). These defects were a result of trauma, post-burn contracted scars, and malignancy requiring a wide excision. Fourteen patients were male and six were female and the ages ranged from 8 to 43 years (mean 10 years). all patients underwent reconstruction by medial sural artery perforator flap. Doppler ultrasound and CT angiography were performed to evaluate the location, number, and size of MSAPF perforators.

Result: Flap survival was uneventful, as 2 (10.0%) patients with Tip necrosis healed with dressing, 3 (15.0%) patients with partial graft loss at the donor site healed by secondary intention, and 3 (15.0%) patients with wound dehiscence healed with frequent dressing. The follow-up ranged from 3 to 13 months with a mean of 7.75 ± 2.95 . The Mean Operative Time (min) was 119.10 ± 21.98 , the Pedicle Length (cm) ranged from 5.5 to 12 with a mean of 9.15 ± 1.76 , and The mean Post-Operative Hospital Stay (day) was 13.30 ± 7.04 . Perforator numbers ranged from 1 to 3 with a mean of 1.25 ± 0.44 . Our results showed that CT angiography was accurate in all cases.

Conclusion: Pedicle MSAP Flap is a versatile pliable flap and has along reliable pedicle with little donor site problems. It is a good reconstructive option for knee and peri-knee defects as it provides an aesthetically pleasing reconstruction with little donor site morbidity.

Keywords: Medial Sural Artery Perforator flap; Knee coverage; Knee Reconstruction.

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INTRODUCTION

There are variant etiologies for the knee defects including trauma, malignancy, implant, burn, and infection. These defects are challenging due to exposed vital structures (patellar tendon, bone, nerve, joint, or exposed implant) which need stable soft-tissue coverage.¹

Many flaps have been described as peri-knee defects. Myocutaneous flap, medial and lateral head gastrocnemius muscle flap, Vastus lateralis muscle flap, vastus medialis muscle flap, pedicled gracilis flap, local fasciocutaneous flaps anteromedial thigh flap, reverse-flow anterolateral thigh flap, the lateral supragenicular perforator flap.²

The medial and lateral sural arteries, which provide nourishment to each head of the gastrocnemius, release some myocutaneous perforators that feed the skin of the posterior calf.³

The superficial sural artery system supplies the medial sural perforator flap, in a supra-fascial plane. It's the largest branch in this network is the median superficial sural artery, which runs along with the lesser saphenous vein.

The medial sural artery usually originates from the popliteal artery (from a common sural trunk in up to 30%).

After a few centimeters, the medial sural artery passes through the medial belly of the gastrocnemius

muscle giving some perforators to the skin. The MSA generally separates into lateral and medial branches, which happens in the muscle substance (85 percent). Because the lateral (nearer the midline) row of perforators is frequently dominant, some surgeons prefer to utilize it. Muscle devascularization is not a major concern, as there are other vascular supplies to the muscle apart from the MSA.⁴

In this study, the versatility of the medial sural artery perforator flap was evaluated for peri-knee soft tissue reconstruction.

PATIENTS AND METHODS

This work has been performed in the plastic surgery department. Al-Azhar University Hospitals Between February 2019 and November 2021, twenty patients with peri-knee soft tissue defects covered with MSAPF to protect vital structures or to prepare for the radiotherapy, all of them gave informed written consent. The study Performed in accordance with the Board of Plastic Surgery. Fourteen patients were male and six were female and their ages from 8 to 43 years (mean 10 years).

7 patients with post-burn unstable scar, 6 patients with a raw area (4 patients were post-traumatic and 2 patients were post-burn), 3 patients post tumor resection (two of the tumor were osteosarcoma and one was multiple myeloma), 3 patients with a post-traumatic unstable scar and one patient raw area after local flap failure.

The knee defects were in the anteromedial side (6 patients), anterior, patellar, pretibial (5 patients), popliteal fossa (7 patients), and lateral side of the knee (2 patients). The defect size was from 7.2 to 20.8 cm.

All patients were assessed using two main modalities: Doppler ultrasound and CT angiography to detect the location, number, and size of the MSAPF perforator.

For each patient the subsequent records were in use:

- Preoperative and postoperative photographs (anterior, lateral, medial, and posterior views).
- Preoperative CT angiography and Doppler for detection of number, and location of MSAPF perforators.
- Plain x-ray to detect bone fracture or osteomyelitis.
- Defect size (cm²) after debridement and release of the contracture.

Radiological examination:

- CT angiography:

The CTA evaluation conformed with the location to be held in the surgical room throughout the surgery. The medial sural artery perforators were investigated for the site and course and caliber by extreme intensity projections and size rendering. The positions of the perforators were labeled on the skin of the case in connection to fixed bony landmarks (medial femoral epicondyle). The radiologist marked the anatomical site of the perforator, its origin, and

course with bony landmarks, e.g. medial femoral epicondyle, lateral and medial malleoli.

The patient was placed on a table of computed tomography in a prone position. A cross coordinate was marked on both hind lower extremities. between the popliteal crease midpoint and the Achilles tendon a line was drawn as the y axis. The proximal one-third point of the line was defined as the intersection (origin) of the y-axis and x-axis. The inner and upper directions Mentioned as positive guidance. A 100ml dose of Ultravist 370 (Schering AG, Berlin, Germany) Intravenously at a rate of 3 ml/sec by contrast. CT cuts were taken from the symphysis pubis above till the end of the foot below. (table 1 shows Computed tomography angiography acquisition data)

The number of MSAPs ranged from 1 to 4 (56 perforators were found during surgery in 20 patients; 1 perforator was found in 3 [12%], 2 perforators were found in 14 [56%], 3 perforators were found in 7 [28%], and 4perforators were found in 1 [4%] Fifty-two perforators (92.86%) were accurately found using vascular ultrasonic localization. The most sizeable myocutaneous perforators are located within 12cm (plus or minus 4) in adults and variable in children (8-10 cm) from the popliteal fossa crease.

Parameter	Description
Scanner	GE 128 Slice CT scan machine
Slice thickness	128-detector row, 0.625 mm collimator width
Helical detector pitch	0.9375
Gantry rotation speed	0.6 sec/rotation
Tube potential	120 KV
Tube current	469 mA
Contrast Injection rate	Optiray 350, 100 ml IV injection 4 ml/sec
Scanning range: Thigh	iliac spine to knee
Leg	From knee to ankle
Scanning direction	Cranial to caudal
Bolus tracking method	From the descending aorta (130 HU)
Scan time: Thigh	10 sec
Leg	15 sec
Imaging reconstruction	MIP(Maximum Intensity Projection), VR(volume-rendering)
Thickness	1.0 mm
Increment	0.7 mm

Table 1: Computed tomography angiography acquisition data.

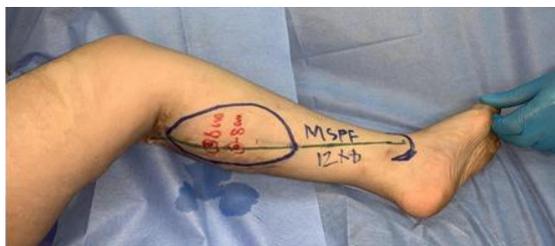
Doppler:

Using AHDU device with 8 MHZ probe (Huntleigh Multi Duplex II Bi-Directional Doppler, HNE Diagnostics, Cardiff, UK). Doppler was used to

confirm the site of the perforator detected by CTA and to double-check with the CTA

Flap design:

The flap was designed by marking the perforator, a line was drawn from the medial malleolus to the midpoint of the popliteal fossa posteriorly. A handheld Doppler is then moved along this line to identify any perforators. (Fig.1)



Surgical technique:

The patients underwent spinal or general anesthesia. pneumatic tourniquet used without limb exsanguinations, the perforators numbers varied from two to four, and usually two reliable perforators were found. The most sizeable myocutaneous perforators were located within 13cm (plus or minus 3) in adults and variable in children (9-10 cm) from the popliteal fossa crease nearly similar to that identified by ct angiography. (Fig.2)



Fig.2: Cutaneous perforators of the medial sural artery numbers from two to four

The flap size was determined by the defect size, after refreshment of edges and debridement, or contractures release. The perforator designed to be at the center of the flap . The medial flap border was elevated to confirm the perforators size and locations. (Fig.3)

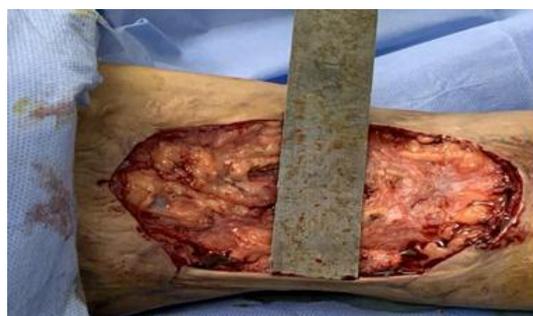


Fig.3: Measurement of the size of the defect after defect release

Intraoperative, we found that the detected place of the perforator with the CT angiography matched with the Doppler

Once a sizeable perforator were identified, the lateral border of the flap is incised and the flap is elevated,

retrograde dissection of the muscle the pedicle is separated from the medial head of the gastrocnemius muscle, After reaching the appropriate length of pedicle the flap was reached. The lesser saphenous vein and sural nerve and were preserved. (Fig.4)

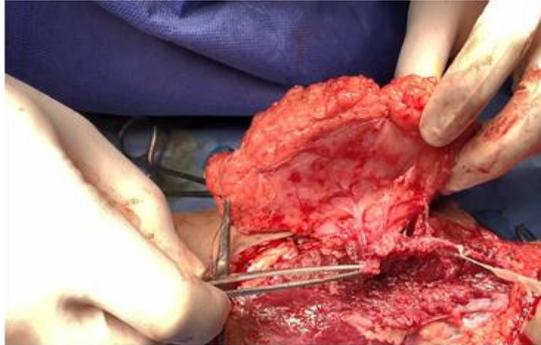


Fig.4: Harvesting of the flap and pedicle dissection

After blood flow to the flap was tested on tourniquet release, the flap is transferred to the knee defect, The donor-site defect was closed directly when the skin elasticity is sufficient and the width of the skin flap is <6 cm, A large donor-site defect (more than 6 cm in width) were covered with a split-thickness skin graft. (Fig.5)



Fig.5: Setting of the flap and donor site coverage by split-thickness skin graft.

Post-operative:

Early Postoperative, In addition to proper dressing and medications, the knee was immobilized for 2 weeks in a short-leg splint with adequate flap monitoring. Flap monitoring depends mainly on clinical assessment of the flap as regards color, capillary refilling, and temperature.

Late post-operative, passive, and active mobilizations were started carefully two weeks after surgery. Followed-up monthly for one year.

Statistical Analysis:

SPSS (Statistical Package for Social Sciences) version 22 for Windows® was used to code, process, and analyze the obtained data (IBM SPSS Inc, Chicago, IL, USA). The Shapiro Walk test was performed to determine whether the data had a normal distribution. Frequencies and relative percentages were used to illustrate qualitative statistics To compute the difference between two or more sets of qualitative variables, apply the Chi-square test (χ^2). The mean and standard deviation (SD) were employed to convey quantitative data (Standard deviation). To compare two independent groups of normally distributed variables, the independent samples t-test was utilized (parametric data). P values of < 0.05 were deemed substantial.

RESULTS

Twenty patients with peri knee soft tissue defects were covered with MSAPF, all of them gave informed written consent. The study Performed in accordance with the Board of Plastic Surgery. Fourteen patients (14) were males and six (6) were females and their ages were from 8 to 43 years (mean 10 years).

Table (2) shows that 13 males and 7 females and their ages were from 8 to 43 years (mean 13.45 years).

		No.= 20
Age	Mean ± SD	13.45 ± 8.32
	Range	8 – 43
Sex	Male	14 (70.0%)
	Female	6 (30.0%)

Table 2: Distribution of the studied cases according to Age and Sex

Cause	No.	%
Post-burn unstable scar	7	35.0%
Row area	6	30.0%
Post-traumatic unstable scar	3	15.0%
Post tumor resection	3	15.0%
Row area after local flap failure	1	5.0%

Table 3: Distribution of the studied cases according to Cause

Table (3) shows that 7 (Seven) patients were with post-burn unstable scar, 6 (six) patients with raw area, 3 (three) patients with post-traumatic unstable

scar, 3 (three) patients post tumor resection, and 1 (one) patient row area after local flap failure.

		No.= 20
Defects	Popliteal fossa area	7 (35.0%)
	Anterior	6 (30.0%)
	Patellar and pretibial region	5 (25.0%)
	Lateral region of the knee	2 (10.0%)
Defect size (cm)	Mean ± SD	11.6± 4.5
	Range	7.2 – 20.8

Table 4: Distribution of the studied cases according to the type of defects and defect size (cm).

Table (4) shows that the knee defects were in the anteromedial side (6 patients), anterior, patellar, pretibial (5 patients), popliteal fossa (7 patients), and lateral side of the knee (2 patients). The defect size was from 7.2 to 20.8 cm.

		No.= 20
Operation. Time (min)	Mean ± SD	119.10 ± 21.98
	Range	79 – 150
Pedicle Length (cm)	Mean ± SD	9.15 ± 1.76
	Range	5.5 – 12
Method of Donor-Site Closure	Graft	16 (80.0%)
	Direct	4 (20.0%)
Post operative. Hospital Stay (d)	Mean ± SD	13.30 ± 7.04
	Range	1 – 35
Perforator number	Mean ± SD	3.25 ± 0.44
	Range	2 – 4

Table 5: Distribution of the studied cases according to Operation Time (min), Pedicle Length (cm), Method of Donor-Site Closure, Post operative. Hospital Stay (d) and Perforator number

Table (5) shows the Mean Operative Time Was 119.10 ± 21.98, the Pedicle Length (cm) ranged from 5.5 to 12 with a mean of 9.15 ± 1.76; there were 16 Patients with Direct and 4 Patients with Graft, The mean Post operative. Hospital Stay (d) was 13.30 ± 7.04 and the Perforator number ranged From 1 to 2 with a mean of 1.25 + 0.44.

Complications		No.	%
Flap Related	None	18	90.0%
	Tip necrosis	2	10.0%
Donor Site-Related	None	14	70.0%
	Partial graft loss	3	15.0%
	Wound dehiscence	3	15.0%

Table 6: Distribution of the studied cases according to Complications

Table (6) shows the Complication, as there were 2 (10.0%) patients with Tip necrosis, 3 (15.0%) patients with Partial graft loss, and 3 (15.0%) patients with wound dehiscence.

		No.= 20
Follow-up (mo)	Mean ± SD	7.75 ± 2.95
	Range	3 – 13
Outcome	Good	18 (90.0%)

Table 7: Distribution of the studied cases according to Follow-up (months) and Outcome

Table (7) shows that the Follow-up range was from 3 to 13(months) with a mean of 7.75 ± 2.95 and all patient's outcomes were accepted just two cases presented with complications

DISCUSSION

Soft tissue defects around the knee represent a reconstructive challenge. These may occur due to different causes such as traffic accidents, gunshot, post-burn contracture release, post- tumor excision, etc.⁵

Skin grafts are often lost due to poor blood supply or inappropriate bed caused by exposed patellar tendon, bone, or implant. Reconstructive choices embrace the utilization of local fasciocutaneous, muscle, and distant free flaps. Although there are many different methods of surgical treatment of knee defects, the optimal treatment remains controversial.⁶

Limited flap range of motion resulting in limitations in completely covering defects in the superolateral side of the knee and in front of tibial tuberosity, donor-site morbidity, and grafting are the main disadvantages of the gastrocnemius muscle flap.⁷

The medial sural artery perforator flap (MSAPF) is a thin fasciocutaneous flap similar to the normal skin and soft tissue around the knee and therefore replacing like with like gives good contour without skin graft.⁸

This prospective study aimed to evaluate the versatility of the pedicled medial Sural perforator flap as a regional flap in the reconstruction of knee and peri knee soft tissue defects.

Our results showed that the indications of this flap were defects at the knee, peri-knee region caused by post-burn unstable scar, raw area, post-traumatic unstable scar, post tumor resection, and raw area after local flap failure. Their sites were in the anteromedial region of the knee, the popliteal fossa, the anterior, patellar, pretibial region, and the lateral region of the knee. The defect size ranged from 7.2 to 20.8 cm.

This was in agreement with several anatomical studies that have been used for MSAP flap. In these studies, the dimensions of the flap were 9.4 cm x 5.5 cm, which shows a close correlation with other similar studies.⁹

The maximum pedicle length in our study was 11.5 cm, which depends on the chosen perforator location. 1 to 4 perforators have a constant sites described which make the MSAPF reliability.¹⁰

In our study, the Mean Pedicle length was 10.5 cm, which looked the same compared to others. The range of perforators was 1 to 4, which is also similar compared to anatomical studies which were 1 to 8. The mean arterial diameter was 1.9 mm and the vein

was 2.9mm, which was also confirmed by other studies.¹¹

In our study, 80% of cases required STSG for closure of the donor site compared to 20% in other studies. This may be attributed to smaller defects in other studies cases and thus needing a smaller flap for reconstruction of such small defects.¹²

In our study, Donor site dehiscence was reported in 3 cases (15%); which was like the results of the other studies that showed donor site dehiscence in up to 25% of cases.¹³

An overall donor site morbidity rate of 1.9% as shown in the 2019 systematic review and meta-analysis performed by Daar et al.¹⁰ showed the MSAP to have a low donor site morbidity rate, which was in agreement with our study that showed there was no donor site morbidity in 14 cases, partial loss in 3 cases and only 3 cases with wound dehiscence.

The caliber of the artery has been reported to be quite small and ranges from 1.1 to 3 mm nearly similar to our study.¹⁴

Regarding the complications presented with the flap, there were 2 (10.0%) patients with Tip necrosis, 3 (15.0%) patients with Partial graft loss, and 3 (15.0%) patients with wound dehiscence.

This was in accordance with Toyserkani and Sorensen¹¹ had no donor site complications. While Han SE et al.¹⁵ had 2 (7.5%) donor sites' morbidity in the form of wound dehiscence.

In accordance with our results, an overall flap success rate was 95%. Only 2 cases showed necrosis compared to other literature stating a total loss of 3.1% and partial loss 3.1%. The most common cause of flap failure was venous congestion compared to the same as stated by Daar et al.¹⁰.

The main drawback of this flap is the donor site scar which is visible on the dorsal aspect of the leg. Lin et al.¹⁶ reported that donor sites about 6 cm could be directly closed. The scar is more noticeable if a skin graft is used for donor site sealing. The aesthetic considerations should be in mind in patient selection.

Our study showed that Patients with defects in the knee region treated with a pedicled MSAP flap had a good color, and texture matching and alleviates the risk of skin graft contracture.

CONCLUSION

Pedicle MSAP Flap is a versatile pliable flap and has along reliable pedicle with little donor site problems. It is a good reconstructive option for knee and periknee defects as it provides an aesthetically pleasing reconstruction with little donor site morbidity.

Conflict of interest : none

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