Received: 20 October 2015 | Revised: 20 December 2016 | Accepted: 5 January 2017

DOI 10.1002/micr.30158

CLINICAL ARTICLE

WILEY MICROSURGERY

Medial sural artery as a salvage recipient vessel for complex post traumatic microvascular lower limb reconstruction

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Funding information
None.

Background: Complex lower extremity trauma still poses a formidable challenge for micro vascular reconstruction. The extensive surrounding zone of trauma can make it difficult to find a suitable recipient pedicle for anastomosis. A need was felt for exploration of newer recipient vessels in lower extremity which could be harnessed for reliable and tension free micro anastomosis. The purpose of the present report is to highlight the possibility of using medial sural artery for safe micro vascular anastomosis in selected scenarios like vessel depleted extremity.

Methods: Between 2008 and 2013, we used the medial sural vessels for micro anastomosis in 10 cases of lower extremity trauma. All the cases had severe soft tissue trauma with or without a bony defect. A computed tomography angiogram (CTA) of the involved extremity revealed either severe perivascular scarring around the standard recipient vessels or patency of just a single vessel. However, in all cases a patent medial sural pedicle was identified on CTA. Interposition vein grafts (IVGs) were used in most cases to ensure a tension free anastomosis.

Results: In all cases, unscarred medial sural vessels were identified with average dissected length and diameter being 6.2 cm (range 4 to 7.5 cm) and 2 mm (range 1.5 to 2.5 mm) respectively. Vein graft [average length 5.6 cm (range 4 to 15 cm)] was interposed in seven cases, while in remaining three, long saphenous vein was used for vein anastomosis. All the flaps survived after the surgery. There was one re-exploration for evacuation of peri-anastomotic hematoma with no adverse effect on flap survival. The mean follow up period was 27.6 months. In the four cases with bone reconstruction, bony union was seen between 5 and 8 months. They were able to walk without aids and resume work after 10–14 months, following a structured rehabilitation program. The patients with soft tissue reconstruction (6 cases) could carry out aid free locomotion and resume their routine after 4–6 weeks. There were no long term complications in any of the flap.

Conclusions: Medial sural artery may prove to be a reliable recipient pedicle for use in complex lower extremity trauma cases and could possibly provide a safer alternative in cases with severe perivascular scarring or in a "single vessel" extremity.

1 | INTRODUCTION

Free tissue transfer has become the standard procedure for post traumatic lower extremity reconstruction. With increasing magnitude of road traffic accidents, cases with intact lower extremity nerves but lacking a good recipient pedicle are not uncommon. In such a scenario, the selection of optimal recipient vessel is one of the most important factor for success of the procedure. However, the same becomes extremely difficult in cases of severe trauma, especially when computed tomography angiogram (CTA) showing perivascular scarring around the standard leg vessels like popliteal, anterior or posterior tibial artery. Similarly, this holds true even in cases with just a single patent vessel where any attempt to harness it for micro anastomosis may interfere with vascularity of the entire distal extremity. Such a scenario mandates exploration of newer recipient vessels for micro anastomosis of free flaps. The medial sural artery has been described as a potential recipient vessel for free tissue transfer in lower extremity (Johnson, Harris, Nagle, & Lewis, 1987).

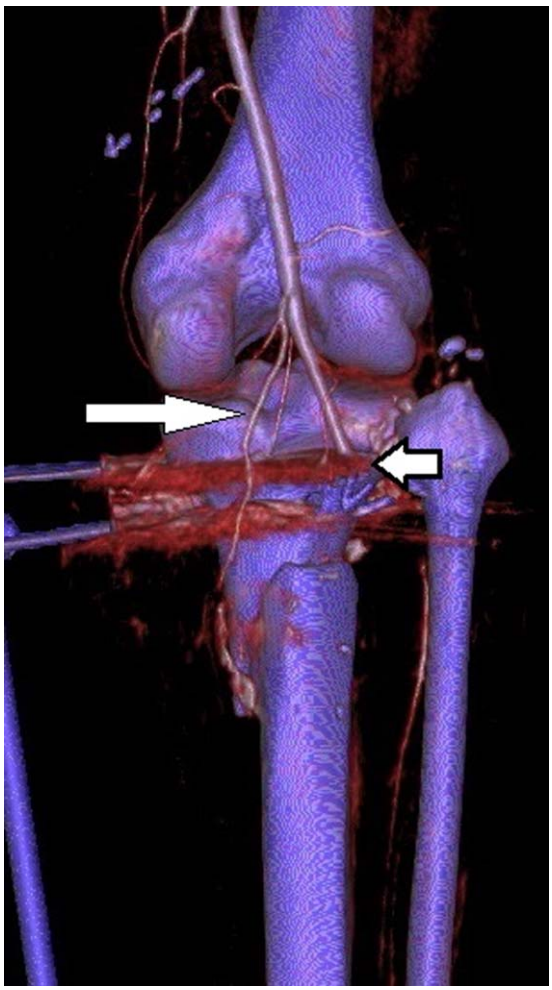

FIGURE 1 CT angiogram of lower extremity. White small arrow shows disruption of popliteal artery with loss of visualization of posterior tibial vessels. Long white arrow shows the healthy segment of the medial sural artery

Herein we report a series where the medial sural vessels have been used as recipient vessels for specific indications like presence of single patent vessel or cases with severe perivascular scarring around all standard leg vessels and additional severe injury to gastrocnemius muscle belly.

2 | PATIENTS AND METHODS

Between 2008 and 2013, 10 lower extremity micro vascular reconstructions were done using medial sural vessels as recipient vessels. All were male patients with age between 15 and 50 years. Six of them were injured in motorbike accidents while the remaining were pedestrians involved in motor vehicular accidents. There were 6 middle third, and 2 each of upper and lower third leg defects. In 4 instances, there was a bony defect that ranged from 5 cm to 8 cm. The mean cutaneous component of the defects was 14.7 cm (range 10–23 cm) by 8 cm (range 5–12 cm). Although specific scoring system was not used, only patients having potential for good functional outcome were considered for intervention. Thus, patients with neurological deficit or severe sepsis in the affected limb were not considered for reconstructive procedures. Similarly, cases with associated chronic medical disorders were excluded. All the included cases had either a single patent standard artery or severe perivascular scarring and gastrocnemius muscle injury. Vascular status of the involved extremity was assessed preoperatively with CT angiography (Figure 1). Patient's clinical details including age, sex, flap parameters, vessel size, anastomosis site, vein graft requirement and flap complications are recorded in Table 1.

2.1 | Surgical technique

The medial sural pedicle was exposed from an incision over medial aspect of the lower thigh passing across the knee joint and extending distally up to the upper part of the leg (Figure 2) (Hallock, 1994). Gentle dissection between the medial gastrocnemius head and soleus muscle helped to identify the medial sural vessels. Exposure was aided by retraction of the gracilis, semi membranous, and sartorius tendons. The medial gastrocnemius belly was partially cut, when the situation warranted dissection high in the popliteal fossa so as to get a longer length of the vascular pedicle (Figure 3). The dissection could be easily performed not only in supine position but also in the lateral position (for latissimus dorsi muscle flap transfer). Anastomosis was always performed in an end to end fashion. In cases where direct vascular anastomosis was not possible, interposition vein grafts (IVG) were used (Figure 4). The IVGs were harvested from the contralateral long saphenous, short saphenous or the cephalic vein. For venous anastomosis, long saphenous vein was used as recipient vein in three patients. Penrose drains were kept near the anastomotic site in all cases. The extremity was splinted in above knee foot drop splint in the postoperative period. Monitoring of anastomosis was done by clinical observation as well as by hand held Doppler. A low threshold of surgical re exploration was maintained.

3 | RESULTS

The flaps used for reconstruction were the anterolateral thigh, osteocutaneous fibula and latissimus dorsi muscle flap transfer. The skin paddle length ranged from 10 to 23 cm while the fibular bone segment was between 5 cm and 8 cm. The dissection was performed in the supine position in 9 cases and in the lateral position for latissimus dorsi transfer in 1 case. In all cases, the medial sural vessels were identified and found to be healthy with unscarred surrounding tissue. An average medial sural pedicle length of 6.2 cm (range 4 to 7.5 cm) could be dissected. The average diameter of the artery was 2 mm (range 1.5 to 2.5 mm). Interposition vein grafts were used in seven cases for ensuring tension free anastomosis. The average length of the IVGs was 5.6 cm (range 4 to 15 cm). In three cases, the adjoining long saphenous vein was used for vein anastomosis. All the flaps survived completely. In one of the anterolateral thigh flap, re-exploration was done after 7 hours for draining peri-anastomotic hematoma. However, the anastomosed vessels were found to be patent with pulsatile arterial flow. There was only minimal epidermal loss which was successfully

TABLE 1 Clinical patient data: Flap and vessels characteristics

Patient	Sex/ Age	Mode and type of Injury	Location	Flap	Skin paddle size (cm) Length × Width; Bone defect (cm)	Recipient vein	Donor pedicle length (cm)	Medial sural Pedicle length (cm)	Vein graft Length (cm)	Diameter Medial sural artery (mm)	Flap survival and Complications	Follow-up (months)	Outcomes
1	M/ 17	Motorbike; Compound, communited tibia fracture	Middle third leg	FFF	15x 7; 5	MSVC	6	5.5	NO	2	Complete flap survival; Uneventful	60	Bony union at 6 months; Routine resumed by 12 months
2	M/ 27	Pedestrian/ Four wheeler; Compound, communited tibia fractures	Middle third leg	FFF	10x6; 7	Saphenous	5	5	8	2	Complete flap survival; Uneventful	40	Bony union at 7 months; Routine resumed by 14 months
3	M/ 25	Motorbike; Compound tibial fracture	Lower third leg	ALT	20x10	Saphenous	5	7.5	15	2	Peri-anastomotic hematoma drainage at 7 hours; minor epidermal loss	24	Routine resumed by 6 weeks
4	M/ 35	Motorbike; Compound tibia fracture	Upper third leg	ALT	18x10	MSVC	7	6	NO	2.5	Complete flap survival; Uneventful	20	Routine resumed by 6 weeks
5	M/ 42	Pedestrian/Four wheeler; Compound tibial fractures	Middle third leg	ALT	10x7	MSVC	10	7.5	8	2	Complete flap survival; Uneventful	36	Routine resumed by 4 weeks
6	M/ 50	Pedestrian/Four wheeler; Compound tibial fractures	Middle third leg	ALT	15x9	MSVC	9	7	6	2.5	Complete flap survival; Uneventful	30	Routine resumed by 5 weeks
7	M/ 23	Motorbike; Communited tibia-fibula fractures	Middle third leg	FFF	12x8; 8	MSVC	6	4.5	7	1.5	Complete flap survival; Uneventful	18	Bony union at 7 months; Routine resumed by 12 months
8	M/ 23	Motorbike; Compound tibial fractures	Lower third leg	LD	12x5	MSVC	6	6	7	2	Complete flap survival; Uneventful	21	Routine resumed by 6 weeks
9	M/ 39	Pedestrian/Four wheeler; Compound, communited tibia-fibula fractures	Middle third leg	ALT	23x12	MSVC	5	7	5	2	Complete flap survival; Uneventful	15	Routine resumed by 6 weeks
10	M/ 41	Motor vehicle accident; Communited tibia-fibula fractures	Upper third leg	FFF	12x6; 7	Saphenous	6	6	NO	1.5	Complete flap survival; Uneventful	12	Bony union at 5 months; Routine resumed by 10 months

ALT, Anterolateral thigh flap; FFF, Free osteocutaneous Fibula Flap; LD, Latissimus dorsi muscle flap; MSVC, Medial sural venae comitantes.

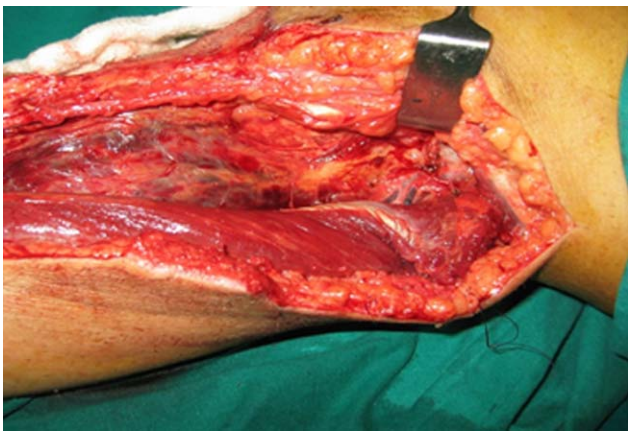

FIGURE 2 Medial approach showing exposed medial sural vessels

managed conservatively. For the donor sites, split skin grafts were used with resultant uneventful healing. Mean follow up period was 27.6 months (range 12 to 60 months). In the four cases where bone reconstruction was done, bony union with the native tibia was achieved between 5 and 8 months (Table 1). These patients had to undergo further physiotherapy and could walk without any aids and resume work between 10 and 14 months. In cases with soft tissue reconstruction, patients were able to start weight bearing and get back to their routine work in 4–6 weeks. None of the patients had residual disability at the end of their follow up period. No late complications were documented in any of the cases.

4 | CASE REPORTS

Case 1

A 27 year old male was injured by an approaching four wheeler while walking on the street. There was left sided upper and middle third region compound tibia fracture and anterior tibial artery laceration. There was a 6 cm bony defect with overlying soft tissue loss of 9 cm

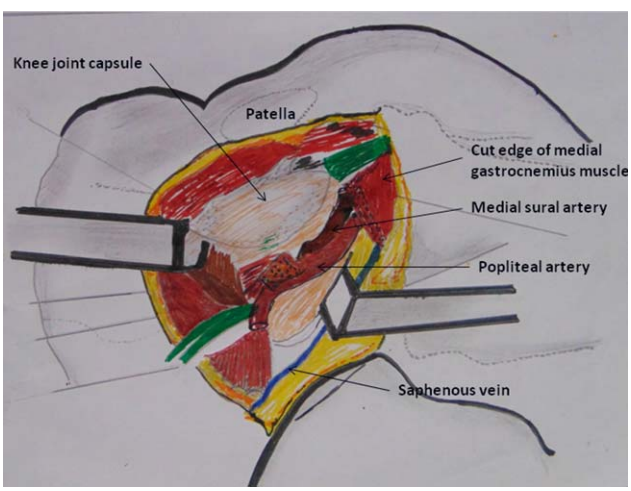

FIGURE 3 Schematic representation of medial aspect of knee and popliteal fossa

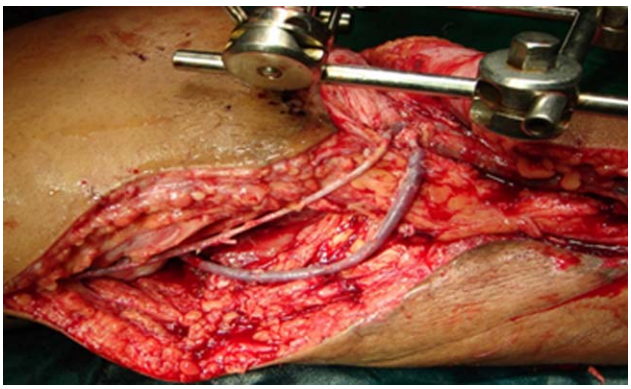

FIGURE 4 Use of long segment vein grafts to bridge the gap between the arteries. Long saphenous vein was used as recipient vein

by 5 cm. (Figure 5A). Radiology showed patent posterior tibial artery with fibrosis around lower popliteal artery and its bifurcation. A double barrel osteocutaneous fibula flap (Figure 5C) with each bone barrel measuring 7 cm and skin paddle of 10 cm by 6 cm was planned with medial sural (Figure 5B) vessels as recipient pedicle. Both the donor and recipient artery length was 5 cm. An interposition vein graft of 8 cm was used for tension free anastomosis. Venous drainage was through long saphenous vein. The donor site was resurfaced with split skin graft. The patient was followed up for 40 months. There was uneventful recovery (5D) and bony union was seen at 7 months. The patient started aid free weight bearing by 11 months and resumed work by 14 months. There were no long term complications or any residual disability at the end of the follow up period.

Case 2

A 35 year old male had a high velocity motorbike accident and was diagnosed to have a right sided compound tibia fracture. The patient was referred 7 weeks later following a failed free flap (done elsewhere with posterior tibial recipient vessel). The patient presented with a 16 cm by 7.5 cm infected wound in the upper third of leg with exposed patellar tendon (Figure 6A). Since the anterior tibial vessels were found to be in zone of trauma, medial sural pedicle (Figure 6B) was used to vascularize an ALT flap (Figure 6C). The ALT skin paddle was 18 cm by 10 cm with pedicle length being 10 cm. Anastomosis was done in end to end manner in this case. Venous drainage was through the medial sural venae comitantes. There was an uneventful recovery. The patient was followed up for 20 months. He was able to achieve aid free locomotion and resume normal activity after 6 weeks (Figure 6D). No residual disability was noted till the last follow up visit.

5 | DISCUSSION

The sural arteries are direct muscular branches of the popliteal artery, originating at or above the level of tibial plateau. Medial and lateral branches supply the respective gastrocnemius muscle and the median branch supplies the overlying skin (Cormack, George, & Lambert,

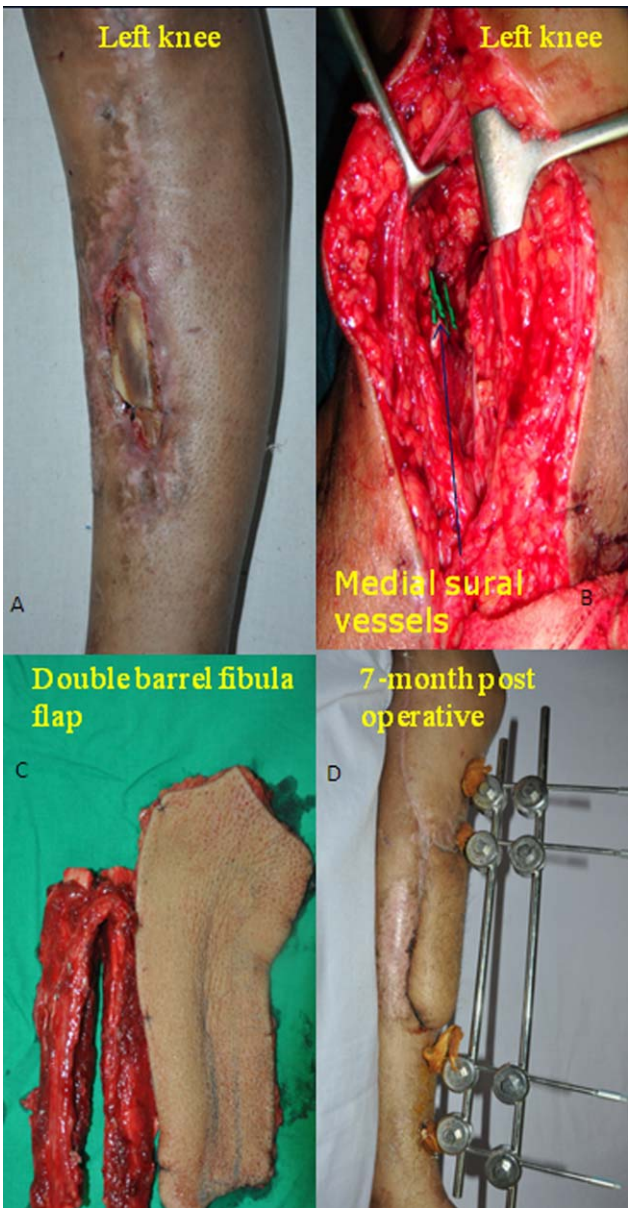

FIGURE 5 (A) Left middle third leg defect. (B) Medial sural vessels dissected. (C) Ostoecutaneous double barrel fibula flap harvest completed. (D) 7 month post-operative status

1994). The anatomy is fairly constant though some variations have been observed. The medial and lateral may arise from a common trunk before dividing to supply the respective head of the muscle and median branch may be absent. The medial is longer with large diameter compared to lateral and median branches. Johnson et al found an average vessel length of 5–7 cm with diameter of 1.5–2.5 mm (Johnson et al., 1987).

The reporting unit is a tertiary microsurgical centre. Lower extremity trauma patients from peripheral centers are referred for definitive reconstruction after receiving primary care and stabilization. However, factors like nerve injuries that adversely influence functional outcome were carefully evaluated. None of the patients in the current series had any associated nerve injury. Thus, the situation was that of young patient without nerve deficits, chronic medical disorders or limb ischemia. Consequently, decision for salvage and definitive reconstruction was straight forward and limb amputation was not indicated in the included cases. In the five-year period when the above cases were undertaken, nearly 200 microsurgical reconstructions were successfully performed using standard pedicles like anterior and posterior tibial vessels. The current report demonstrates successful functional outcomes by microsurgical reconstruction using medial sural pedicle as recipient vessel. The authors hereby want to highlight this selected case scenario of using the medial sural vessels in vessel depleted lower extremity.

CTA was done to document the vascular status of the major vessels (popliteal, anterior and posterior tibial artery) of the affected limb. Medial sural vessels were also identified and anatomical variations ruled out before deciding about the selection of potential recipient vessels. In our series, eight patients had a single patent vessel and the remaining two had severe perivascular scarring around the major vessels of the leg. Medial sural vessels could be efficiently used as

FIGURE 6 (A) Right upper 3rd leg defect. B) Medial sural vessels dissected as recipient pedicle C) ALT flap inset D) Post-operative status

recipient vessels for free tissue transfer, avoiding the "single patent vessels of the leg", thus avoiding interference with the circulation of the limb.

Johnson et al. (1987) described an oblique incision between the heads of gastrocnemius for exposure of the medial sural vessels. This technique interferes with the vascular connections between the two heads of the gastrocnemius and careful dissection is needed to avoid injury to the motor branch of tibial nerve. Hallock (1994) described a medial approach for easy dissection and prevention of injury to the motor nerve. We have used the medial approach in all our cases without any complications or inadvertent injury to adjacent important structures. This approach also helps in keeping the incision to a bare minimum and can be extended as and when required. We preferred end to end anastomosis in all our cases. It is technically easier and allows mobility of flap during the inset process with resultant fewer anastomotic disruption problems (Johnson et al., 1987). The venous anastomosis can be done with the one of the paired venae comitantes or with the long saphenous vein if it is available. We used long saphenous as recipient vein in three cases. The advantage of long saphenous vein is its superficial location, large caliber and more importantly, avoidance of any kinking. IVGs were frequently used to achieve a secure tension free anastomosis, especially in defects of lower half of the leg. We have used IVGs up to 15 cm length each for artery and vein to bridge the gap between the recipient and flap vessels. Contralateral long or short saphenous veins were used as vein grafts. The cephalic vein may also be used for the same. The use of IVGs in our series has not increased the anastomotic complications. Nelson et al. (2015) did not find any decrease in flap survival following use of IVGs in microvascular reconstructions. Ciudad et al. (2016) also found no complications associated with use of vein grafts. Bayramicli, Tetik, Sönmez, Gürünlüoğlu, and Baltaci (2002) did not find any difference between success rate of vein-grafted free flaps and that of the simple free flap transfers and attributed this to meticulous preoperative planning and proper selection of recipient vessels. The medial sural vessels can be used when the major blood vessels of the limb are unavailable and block in popliteal artery is distal to the origin of the medial sural artery. It can be used when there is perivascular scarring around the major vessels of the leg or in cases of single patent vessel to avoid a compromising situation. It could be recipient vessel of choice in case of single vessel limb (Pyon, Ha, Hyun, Kim, & Shin, 1999). We found well preserved medial sural vessels suitable for use as recipient vessels even in cases of severe injury involving major part of the gastrocnemius muscle. Even in injuries involving distal popliteal fossa level, well preserved vascular segments could be dissected near the muscle origin.

Clinical and experimental studies have demonstrated vascular connections between the two heads of gastrocnemius which provided optimum collateral circulation (Bashir, 1983; Tsetsonis, Kaxira, Laoulakos, Spiliopoulou, & Koutselinis, 2000). Additional distal supply to gastrocnemius has also been observed from the posterior tibial and peroneal vessels (Taylor & Pan, 1998). We did not come across features suggestive of devascularisation of gastrocnemius belly in any of the cases. Beumer, Karoo, Caplash, Semmler, and Taylor (2011) observed limited atrophy of the medial gastrocnemius muscle, however it was not significant and they could confirm preservation of function.

The medial sural vessels have distinct advantages as recipient vessels since the exposure is rapid and safe (Johnson et al., 1987). Anastomosis is possible at a superficial level compared to the popliteal artery, which is located in a deeper plane. Medial sural vessels remain largely protected in injury due to the bulky muscle cover in comparison to anterior and posterior tibial vessels which course along the bony surface. They have reasonable length and a calibre similar to the commonly used donor vessels (Taylor & Pan, 1998). Final anastomosis is also cushioned by the gastrocnemius muscle. It can be used for defects from above knee and down to those over the lower leg level with liberal use of vein grafts. Even in severe mutilating injury of the leg with a small intact segment of gastrocnemius muscle near its origin, the vessels remain largely unharmed under it. It allows the reconstructive surgeon to avoid handling of major limb vessels in cases with precarious vascularity of the limb.

Dissection high into the popliteal fossa may be needed which could lead to increase in the operating time and the anastomosis needs to be carried out in a relatively deeper plane which sometimes may prove to be challenging. Interposition vein grafts may be required in defects of the lower half of the leg. Hence an experienced team with good microsurgical expertise is essential.

There have been reports of use of retrograde arterial flow for free flap anastomoses However, Miyamoto et al. (2008) have found far inferior results in terms of area of flap survival with use of retrograde flow when compared to those with ante grade flow.12

6 | CONCLUSIONS

Medial sural vessels have adequate length and caliber and may be used for micro vascular anastomosis. It may be considered for use in selected extremities with severe trauma and scarring around anterior and posterior tibial vessels in "single vessel extremity".

ACKNOWLEDGMENTS

All authors hereby declare not to have any potential conflict of interests and not to have received funding for this work from any of the following organizations: National Institutes of Health (NIH); Wellcome Trust; Howard Hughes Medical Institute (HHMI); and other(s). Each author participated sufficiently in the work to take public responsibility for the content.

CONFLICT OF INTEREST

None of the authors received any funds or has any financial interests to disclose.

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How to cite this article: Baliarsing A, Date S, and Ciudad P. Medial sural artery as a salvage recipient vessel for complex post traumatic microvascular lower limb reconstruction. *Microsurgery*. 2017;00:1–7. doi:10.1002/micr.30158.