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Clinical application of anterolateral thigh perforator flap for the reconstruction of severe tibia exposure

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Abstract. – OBJECTIVE: Exposure of tibia can result from severe traumatic wounds, such as injuries due to traffic accidents, crush injuries (machine) and amputation wounds. The free anterolateral thigh perforator flap is increasingly being used for trauma reconstruction. Here we report our case load with this surgical intervention.

PATIENTS AND METHODS: We reviewed 27 patients who underwent free anterolateral thigh flap reconstruction for tibia exposure in the proximal-middle part. The flap size ranged from 64 cm^2 to 270 cm^2 (mean, 35 cm^2). The recipient artery was the anterior tibial artery (3 cases), the posterior tibial artery (8 cases), the dorsal pedal artery (8 cases) and the contralateral posterior tibial vessels (8 cases).

RESULTS: Among the flaps, 20 successfully survived (74%), and the others suffered from partial skin necrosis at flap edge (5 cases, 18.5%) and flap loss was caused by venous or arterial thrombosis (2 cases, 7.4%). The lost flap was reconstructed with a split-thickness skin graft or a cross-leg soleus muscle flap coverage. The follow-up period ranged from 3 to 30 months. Three patients had sinus formation and healed in one year with the repeated debridement and drainage. Among the 27 cases, only one case presented reinfection at the sixth postoperative month, due to the plate fixation and was healed in one month by the removal of steel plate and thorough debridement and drainage.

CONCLUSIONS: Our results suggest that free anterolateral thigh flap would be an alternative choice for reconstruction of severe tibia exposure, and careful selection of the location and number of perforators as well as the proper selection of recipient artery are of great importance.

Key Words:
Bone exposure, Reconstruction, Anterolateral thigh perforator flap, Anastomosis.

Introduction

Coverage of bone exposure defects, especially tibia exposure in the proximal-middle part, with skin and soft-tissue still poses challenge to the plastic and orthopaedic surgeons[1-3]. Traumatic wounds, burns, and tibial fractures frequently expose the bone. Because of limited mobility and a paucity of overlying skin, even a small defect in the pretibial area generally needs flap coverage. Local flap would be a good choice as it is a relatively simple operative technique with few medical complications and low risk of flap necrosis[4,5].

However, the local flap is usually not enough to reconstruct large exposure area of tibia with severe traumatic wounds, such as traffic accident injuries, crush injuries (machine/heavy weights) and amputation wounds. The local flap such as the gastrocnemius muscle and hemisoleus muscle flap (large enough to cover the exposure) are often difficult to harvest from the leg with severe trauma. Thus, free flaps are required to cover the exposed bone and reconstruct the soft-tissue defect. The free flaps are preferred not only for their size but also for their robust blood supply[6]. Rodriguez et al[7] have reported that free flap coverage for severe trauma with underlying osseous injuries had fewer wound complications than local rotational flap coverage. Kimura et al[8] recommended the use of a thin anterolateral thigh flap for reconstruction of the anterior tibial area.

Here, we report case load our with 27 patients using free anterolateral thigh flap for the reconstruction of the tibia exposure in the proximal-middle part. Our results suggest that free anterolateral thigh flap would be an alternative choice for reconstruction of severe tibia exposure considering the patient condition.

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Patients and Methods

Patients

Between June 2008 and December 2011, 27 patients (24 male and 3 female patients) underwent the reconstruction of tibia exposure using free anterolateral thigh flap. Informed consent was obtained from each patient and all the studies were approved by our Institutional Ethics Committee. Patients' ages ranged from 18 to 60 years with an average of 41.7 years. The cause of tibia exposure included traffic accident (20 cases), crush injuries (6 cases), and amputation (1 case) (Tables I, II and III). The bone exposure was located in the proximal-middle tibia in the 27 patients; 11 cases were in the proximal tibia and 16 in the middle part of the tibia.

Anterolateral Thigh Flap for the Reconstruction of Tibia Exposure

The recipient vessels were marked after thorough debridement. The patients with bone and/or tendon injury were given treatment to the injury first. Then, a provisional flap design was drawn according to the wound area. The lateral cutaneous branch of the patella femoral artery descending branch was located according to the midpoint between the anterior superior iliac spine and the supero-lateral (upper outer) corner of the patella. After the location of blood vessels was confirmed by a Doppler ultrasound bloodflow detector, flap design was drawn accordingly.

Then the internal edge of the flap was cut, every flap perforator vessel was protected and the branch with largest diameter was chosen as pedicle. If the location of vascular pedicle was distant from the position located by ultrasound, the flap was redesigned according to the pedicle. Where needed the distal edge of the flap was thinned to create a better match. The intermuscular septum perforating branches could keep a longer vascular pedicle, while the muscle perforator had a vascular pedicle cut directly on the surface of the muscle. We obtained flaps containing anterolateral cutaneous nerve, since they could facilitate reconstruction of sensory function. The operation was performed under surgery microscope and the donor area was directly sutured or repaired with full-thickness skin graft according to the area of flaps. Routine administrations such as anti-inflammatory, anticoagulation and anti-spasm were applied after surgery.

Results

The flap size ranged from 64 cm^2 to 270 cm^2, and the mean size was 35cm^2. The recipient artery used was the anterior tibial artery (3 cases), the posterior tibial artery (8 cases), the dorsal pedal artery (8 cases) and the contralateral posterior tibial vessels (8 cases). The arterial end-to-end and end-to-side anastomoses were performed in 19 and 8 patients, respectively. The venous end-to-end and end-to-side anastomoses were used in 20 and 7 patients, respectively. The mean duration of surgery was 252 min (range from 140 to 510 min). The length of hospital stay ranged from 13 to 123 days, with an average stay of 58 days.

Partial skin necrosis at the flap edge occurred in 5 patients, which healed without further intervention (2 cases) or with reexploration (3 cases). Venous thrombosis and arterial thrombosis

Table I. The posterior tibial artery combined the great saphenous vein grafting.

Case No.	Age/ gender	Cause	Location	Size	Vessel anastomosis (A/V)	Venous grafting	Vascular complications	Salvage procedure	Result	Follow-up (mo)
1*	18/M	CM	Middle	18 × 8	ETS/ETE	Yes	None	None	CS	12
2	43/M	TA	Proximal	20 × 8	ETE/ETE	None	None	None	CS	10
3	55/M	TA	Middle	12 × 5	ETE/ETE	None	None	None	CS	6
4	34/M	TA	Proximal	18 × 9	ETE/ETE	None	None	None	CS	25
5	27/M	TA	Proximal	25 × 9	ETE/ETS	Yes	None	None	PF	19
6	56/M	Amputation	Proximal	15 × 10	ETS/ETS	None	None	None	CS	3
7	36/F	CM	Middle	28 × 9	ETS/ETE	None	None	None	CS	8
8	46/F	TA	Middle	18 × 9	ETS/ETS	None	None	None	CS	30

TA: traffic accident; CM: crush injuries (machine or heavy weights); CS: complete survival; PF: partial failure; ETS: end-to-side anastomosis; ETE: end-to-end anastomosis; A/V: artery/vein; *cases in case report.

Table II. Reverse-flow the dorsal pedal artery.

Case No.	Age/ gender	Aetiology	Location	Size (cm^2)	Recipient vessels	Vessel anastomosis (A/V)	Vascular complications	Salvage procedure	Result	Follow-up (mo)
9	48/M	TA	Middle	12 × 9	ATA	ETS/ETE	None	None	CS	15
10	47/M	TA	Middle	21 × 10	ATA	ETE/ETE	Venous thrombosis	Re-exploration	PF	18
11	42/M	TA	Middle	18 × 9	ATA	ETE/ETS	Arterial thrombosis	Re-exploration	TF	6

TA: traffic accident; CM: crush injuries (machine or heavy weights); CS: complete survival; PF: partial failure; TF: total failure; ETS: end-to-side anastomosis; ETE: end-to-end anastomosis; A/V: artery/vein. *Ccases in the case report.

caused flap loss in 2 patients shown in Table II (case 6 and case 11). In case 11, the arterial thrombosis occurred at 10 hours after surgery, which may be the critical cause for the flap compromise. Then, the defect was covered with a cross-leg soleus muscle flap after the flap loss. The flap survived and the pedicle was cut after 39 days. In case 6, there was venous thrombosis at 12 hours post-operation, and the wound was reconstructed with a split-thickness skin graft.

The follow-up period ranged from 3 months to 30 months. Sixteen cases healed at Stage I and 6 cases at Stage II. Three patients had sinus formation and healed in one year with the repeated debridement and drainage. Among the 27 cases, only one case presented reinfection at the sixth postoperative month due to the plate fixation. The wound was healed in one month by removing the steel plate and thorough debridement and drainage. None of the patients had any newly developed functional deficit of the lower leg.

Typical Cases

Case 1

An 18-year-old boy was involved in an accident causing crush injuries in his left tibia (as shown in Table I; case 1). Orthopedic surgeons performed external fixator fixation for tibia fracture and one thorough debridement (Figure 1A). The bone exposure was closed with a free anterolateral thigh perforator musculocutaneous flap (size: 18 × 8 cm; Figure 1B). The great saphenous vein with 9 cm was harvested at contralateral lower extremity and was interposed between the pedicle of the flap and the posterior tibial artery because the pedicle was not long enough to approach the posterior tibial artery. End-to-end anastomosis and end-to-side anastomosis were performed, respectively. The vein anastomosis was performed end-to-side. The donor area was covered by a split-thickness skin graft. Postoperative recovery was uneventful

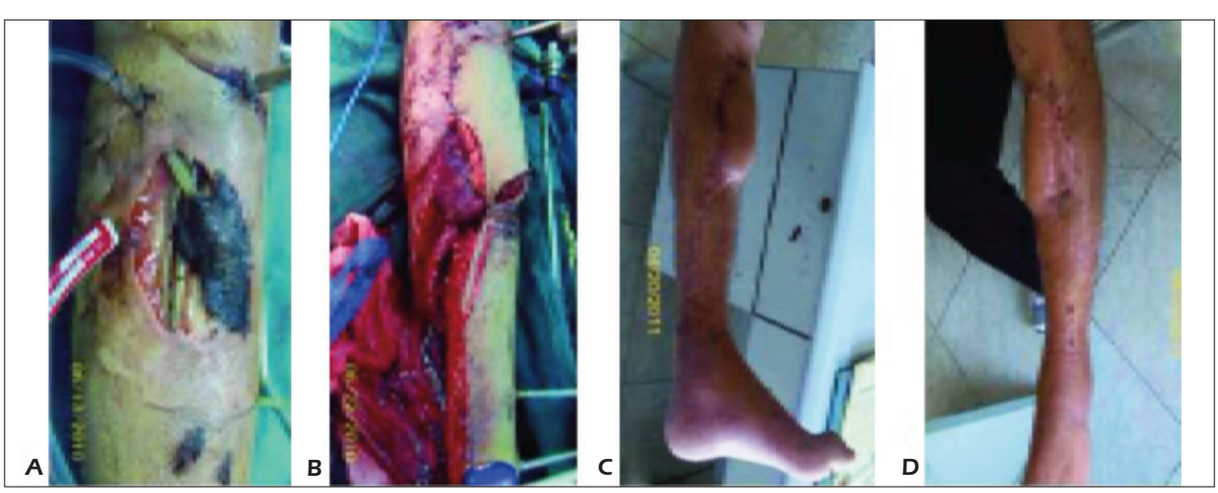

Figure 1. Case 1: Pre- and postoperative figures. ***(A)*** Crush injuries in the left tibia. ***(B)*** Bone exposure was closed with a free anterolateral thigh perforator musculocutaneous flap (size: 18 cm × 8 cm). ***(C-D)*** Pictures of 15 months follow-up.

and at fifteen months follow-up, the flap survived completely and no complications occurred (Figure 1C, D).

Case 2

A 44-year-old male sustained an open tibia fracture in his right lower leg in a motorcycle crash (as shown in Table II; case 1). Orthopedic surgeons performed external fixation for the bone fracture (Figure 2A). After one thorough debridement, a 15 cm × 6 cm free anterolateral thigh perforator flap was used to cover the exposed tibia and soft tissue defect. The pedicle was anastomosed end-to-end to the reverse-flow the dorsal pedal artery and paired venae comitantes that was dissected from the distal ankle joint (Figure 2B). The donor area was sutured directly. The doctor and nurse performed careful follow-up clinical observation and the flap survived successfully. The 12-months follow-up photograph showed excellent soft tissue coverage (Figure 2C) and a well-healed donor site (Figure 2D).

Case 3

A 35-year-old man suffered from a severe crush injury as a result of a traffic accident (as shown in Table III; case 1). The tibia had comminuted fracture and bone exposure (Figure 3A). After the external fixator fixation and three thorough debridements, the free anterolateral thigh perforator musculocutaneous flap (19 cm × 9 cm) was interposed between legs. The contralateral posterior tibial vessel was used as the recipient vessel (Figure 3B). End-to-end microanastomoses were performed. The donor area was primary closure. The pedicle was divided 28 days later and the wound healed well after 12 months (Figure 3C).

Discussion

The anterolateral thigh perforator flap is increasingly being used for trauma and reconstructive surgical cases, with the thinned flap design, greater survivability and reduced donor-site morbidity. It has been one of the most popular alternatives for reconstruction of the neck, axilla and anterior tibial area, etc. Song et al[9] initially presented the free anterolateral thigh flap as a fasciocutaneous flap in 1984. In 1993, Koshima et al[10,11] reported successful application of free anterolateral thigh fasciocutaneous flap in reconstruction of head and neck defects. Perforator flaps have been of interest for many years as they lead to better wound reconstruction effects and less donor-site morbidity. Kimura et al[8] reported clinical application of the free thin anterolateral thigh flap in 31 consecutive patients with anterior tibial area defects, and they recommended the use of anterolateral thigh flap for reconstruction of the tibia. It has been reported that anterolateral thigh perforator flap was successfully used in chronic osteomyelitis of the lower extremity to combat infection and to bring stability to wounds[12].

However, although computed tomography angiography scanning (angio CT scan) remains an

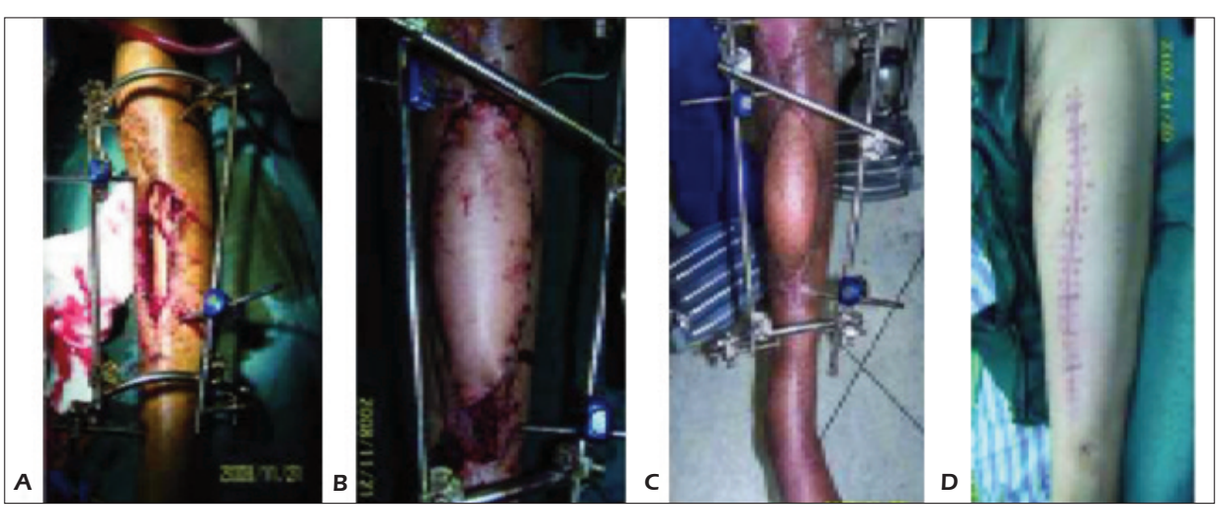

Figure 2. Case 2: Pre- and postoperative figures. ***(A)*** An open tibia fracture in the right lower leg. ***(B)*** A free anterolateral thigh perforator flap (15 cm × 6 cm). ***(C)*** The 12-months follow-up photograph. ***(D)*** A well-healed donor site.

Table III. Contralateral posterior tibial vessels.

Case No.	Age/ gender	Aetiology	Location	Size (cm^2)	Vessel anastomosis (A/V)	Complications	Salvage procedure	Separated time (days)	Result	Follow-up (mo)
1*	35/M	TA	Middle	19 × 9	ETE/ETS	None	None	38	CS	16
2	43/M	TA	Proximal	20 × 8	ETE/ETE	None	None	46	CS	19
3	57/M	TA	Proximal	8 × 8	ETE/ETE	None	None	45	CS	27
4	35/M	TA	Proximal	20 × 9	ETE/ETE	None	None	34	CS	6
5	39/M	TA	Proximal	13 × 8	ETE/ETE	Venous thrombosis	Re-exploration	38	PF	8
6	24/M	CM	Proximal	31 × 4	ETE/ETE	None	None	41	CS	7
7	42/M	CM	Middle	10 × 9	ETS/ETS	None	None	46	CS	5
8	50/M	TA	Proximal	27 × 10	ETS/ETS	None	None	29	CS	21

TA: traffic accident; CM: crush injuries (machine or heavy weights); CS: complete survival; PF: partial failure; ETS: end-to-side anastomosis; ETE: end-to-end anastomosis; A/V: artery/ vein. *Cases in the case report.

asset for medical test allowing material of advanced contrast for high detection rate[13-15] which could have been used for better diagnose, surgery and follow-up of our patients, we did not possess facilities and sufficient commodities at the time of interventions. The present study is a retrospective report of 27 patients using free anterolateral thigh perforator flap (musculocutaneous perforators) for the reconstruction of the proximal and middle of the tibia exposure with on-board resources. Data may be of great interest for physicians lacking of to advanced technologies worldwide. We found that the critical technology for the free anterolateral thigh perforator flap was finding the proper cutaneous perforator. The anterolateral thigh flap is based on the descending branch of the lateral circumflex femoral artery, which lies in the groove between rectus femoris and vastus lateralis. The flap provides numerous branches to the surrounding muscle and/or fascia and septocutaneous and/or musculocutaneous branches to the skin. One large cutaneous perforator would often provide enough blood supply for flaps with general shape, and two perforators could be helpful in preserving the flap, considering the condition of the patients. In our report, 5 patients developed partial skin necrosis at the flap edge, mainly because the ratio of length to diameter exceeded 3:1 in these 5 flaps. Thus, the location and number of perforators should be chosen carefully, especially for slender narrow flaps or for flaps of large dimension. As for the closure of donor site, we suggest skin graft should be performed in width of the flap greater

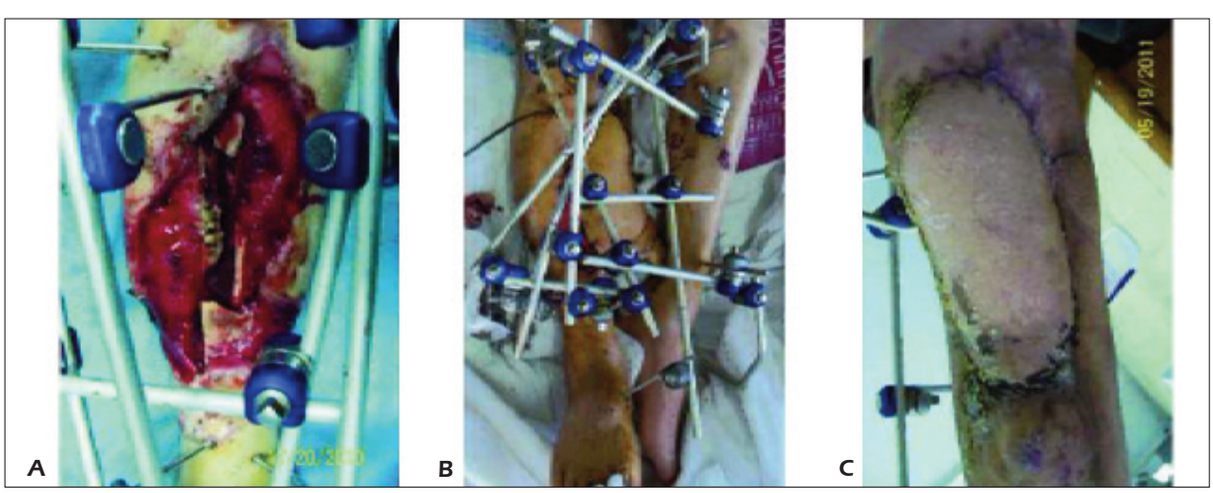

Figure 3. Case 3: Pre- and postoperative figures. ***(A)*** Bone exposure was caused by a traffic accident. ***(B)*** A free anterolateral thigh perforator musculocutaneous flap (19 cm × 9 cm). ***(C)*** The healed wound after 12 months.

than 6 cm, instead of closed primarily. We also found that the fascia lata of the donor site should be sutured first followed by the skin suturation. In our report, one patient suffered from liquefaction of subcutaneous fat due to direct suturation of skin. The wound healed 3 weeks after proper wound care.

The proper selection of the recipient artery is one of the most important factors for a successful flap transfer[3]. Karsidag et al[16] recommended that the posterior tibial artery was a better alternative for recipient artery for its wider caliber and higher flow. Many reports have suggested that the posterior tibial artery is much less vulnerable than the anterior tibial artery in most traumas and it is more reliable as the recipient artery[17-19]. In our study, we used the posterior tibial artery for recipient artery in 8 cases (Table I). However, the deep position of the posterior tibial artery at this level makes the vascular anastomosis challenging[20]. We have harvested the flap with a long pedicle as much as possible. According to the literature[7,21], the pedicle length ranges from 8 to 16 cm and the vessel diameter ranges from 2 to 3 mm. Nevertheless, the pedicle was still short for end-to-side anastomosis with the posterior tibial artery in some cases. We performed great saphenous vein graft combined end-to-side anastomosis technique in 2 cases, which is the best procedure to help us solve this problem, even though the use of vein grafts may increase the risk of vessel thrombosis[3].

The anterior tibial artery and the dorsal pedal artery are relatively superficial and easy to dissect, but they are much more vulnerable in the trauma. Both arteries would be a good recipient artery choice if not damaged during the trauma. However, according to the theory of the "injury zone", the inflammatory response of the soft tissue with the injury results in perivascular changes of the blood vessels. And these changes, such as vascular fragility increase in the perivascular scar tissue, are raising the rate of microvascular thrombosis[22]. It has been reported[23] that vascular anastomosis should be done at the healthy tissues far from this region. However, Basheer et al[24] suggested the use the anterior tibial artery, because it is difficult to delineate the "healthy zone" and the anterior tibial artery is easier to use and more accessible. We used the distal anterior tibial artery in 3 cases and the reverse-flow dorsal pedal artery in 8 cases (Table II). The dorsal pedal artery is relatively far away from the "injury zone" and the rotational angle should be designed perfectly to avoid the sharp rotation.

Conventionally, ipsilateral vessels are selected for the recipient vessels. However, it is usually difficult to prepare some suitable ipsilateral vessels for the recipient vessels after severe trauma, because the lower limb is poorly protected against high-energy injuries[19]. Taylor et al[25] first defined the use of cross-leg free flaps in 1979. Here we report 8 cases using the contralateral posterior tibial vessels as the recipient artery, where end-to-end anastomosis was made in 6 cases and end-to-side anastomosis in 2 cases. The period of the pedicle being divided ranged from 29 to 46 days (average, 40 days). Venous thrombosis was found at anastomotic stoma in one case. Surgical re-exploration was performed after one day and the flap were completely salvaged.

In this study, we report 27 patients who had free anterolateral thigh perforator flap for the reconstruction of the severe tibia exposure in the proximal-middle part. 20 of these flaps successfully survived (74%), partial skin necrosis at the flap edge in 5 cases (18.5%) and flap lost caused by venous thrombosis and arterial thrombosis in 2 cases (7.4%). The proper selection of the recipient artery is one of the most important factors for a successful flap transfer. The recipient artery we chose for our patients was the anterior tibial artery (3 cases), the posterior tibial artery (8 cases), the dorsal pedal artery (8 cases) and the contralateral posterior tibial vessels (8 cases).

Whereas only ALT flap was used in this study, recent comparative study founded that, like latissimus dorsi flaps, this approach meet the requirement of an ideal soft tissue flap in terms of versatility, skin texture and tissue stock as did *latissimus dorsi* flap in soft tissue reconstruction of extensive defects in the head and neck region[26]. ALT perforator flap has also been reported as a precious option for lower extremity soft tissue reconstitution with minimal donor site morbidity[27]. However, novel robot assisted *latissimus dorsi* harvest technique has yield a safe alternative to the conventional method; and thus of interest for the future of flap reconstruction surgeries[28] in equipped station.

Conclusions

Our results suggest that free anterolateral thigh flap would be an alternative choice for reconstruction of severe tibia exposure considering the

patient condition, and careful selection of the location and number of perforators as well as the selection of recipient artery are of great importance.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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