Research Article

Is Sural Artery Flap an Answer for Soft Tissue Coverage of Lower Limb Defects?

Sana saeed[1], Farid ahmad khan[2], Izza khan[3], Sundas javeed[4], Komal saeed[5]

[1-5]*Plastic Surgery Department, Services Hospital Lahore, Pakistan*

Abstract

Introduction: Sural artery flap has proved to be a reliable option to reconstruct soft tissue defects of lower leg with no significant morbidity at donor site. Various modifications of flap harvesting technique like extended, delayed proximally /distally based, islanded/peninsular, nerve sparing have been described in various studies. This study highlights modifications in a single series and their outcomes in lower limb defects

Methods: This is a retrospective observational study including 35 patients of either gender conducted at Plastic Surgery Department, Services Hospital Lahore. Lower extremity defects requiring soft tissue coverage enrolled from March 2020 to March 2021 were included. Demographic data, clinical details about the defect and post-operative complications were noted. Clinical outcomes of the flap on basis of flap size, operative time, wound healing percentage and complication rate were observed.

Results: 35 patients (28 males and 7 females) of mean age of 31.62±13.93 years were included in this case series. The most common cause of lower limb defects was trauma. The ankle and dorsum of foot was the most common location that was covered with extended reverse sural artery flap. Mean flap size was 131.48± 29.46cm^2. Mean operative time was 79.71±18.78 min. The complication rate was 14%. Complete wound healing was 97%±3.

Conclusion: Sural artery flap is a reliable and versatile option for resurfacing soft tissue defects of lower limb. Various modifications can be wisely utilized to increase the efficacy of flap with lesser complications, extended coverage and less operative time especially in an era of COVID -19 infection.

Received | 25-07-2021: **Accepted** | 20-08-2021

Corresponding Author | Senior registrar, Institute: plastic surgery department, services hospital Lahore, Pakistan
E-mail: srdhillon.102@gmail.com

Keywords | Lower limb defects, sural artery flap, extended reverse sural artery flap, Modifications of sural artery flap, delayed reverse sural artery flap.

Introduction

Coverage of soft tissue defects around lower leg has always been a technically tough task due to scarcity of available soft tissue for reconstruction.[1] Free tissue transfer has been a great option for coverage of such defects. Nevertheless, need for sacrifice of major vessels, need for expertise, logistics and prolonged operative time are the limitations of free tissue transfer. In this era of covid-19 pandemics where prolonged operative time and lengthy hospital stay increases the risk of infection, sural artery flap proves to be a versatile and reliable option for wound coverage of lower leg.

After the description of Ponten of fasciocutaneous sural flap in 1981, Donski and Montegut further evolved the clinical application of sural artery flap as an excellent choice for coverage for lower third of leg. In 1992, Masquelet et al introduced the concept of reverse flow sural neurocutaneous flap.[2] The skin of posterior middle third of calf is supplied by medial and lateral superficial sural arteries which are invariably branches of popliteal artery. It is accompanied with sural nerve which provides neurocutaneous vascular plexus. Venous drainage of this region is through lesser saphenous vein. These structures courses in the midline of calf deep between

two heads of gastrocnemius and pierces deep fascia at midcalf level. The main perforating vessels of mid-calf commonly arises from medial superficial sural artery and peroneal artery. It has been described that communicating branches from the neural arterial plexus, lesser saphenous vein arterial network, the adipose arterial network are inter linked that optimizes flap perfusion. However, major contribution is provided by septocutaneousperoneal artery perforators which run into two parallel networks: one for the sural nerve and other for the lesser saphenous.[3]

In last few decades, multiple modifications have been published in literature. With plethora of multiple modifications, this flap can even be used for coverage of defects of larger size and can achieve longer arc of rotation for defect up to forefoot.[12] This study is aimed to evaluate the utility of different modifications of sural artery flap for more complex defects of lower leg for which free tissue transfer can be a good choice.

Outcomes were assessed in term of operative time, flap size, wound healing and complication rate. Although there are a lot of studies available in literature about this flap, however, this study will highlight the importance of less operative time and hospital stay in this phase of epidemics and shows sural artery flap as a good selection for reconstruction of lower limb defects. Moreover, in this study, we tried to infer that in spite of technically difficult defect size and site, sural artery flap proves to be a safe and reliable choice.

Methods

This is a retrospective observational study conducted at Plastic & Reconstructive Surgery Department, Services Hospital Lahore from March 2020 to March 2021. The study protocol was approved by the Institutional Review Board, Services Institute of Medical Sciences / SHL (Ref No. IRB/2021/847/SIMS). Demographic and clinical data of thirty five patients with lower limb defects recruited either through emergency or outpatient department from March 2020 to March 2021 is reviewed. Patients having complete incomplete pre-operative, per-operative findings and follow up less than 3 months were excluded. As per protocol, trauma case were recruited through emergency department after initial resuscitation, debridement and bony stabilization if needed. Patients having wounds around distal one third of leg, ankle, dorsum of foot proximal to toes, heel and knee were included. Patients of age group between 5 years and 60 years of either gender were considered. Patients having peripheral vascular disease and acute wounds around lateral aspect of lower third of leg affecting neurovascular axis were excluded. However, patients having scarring in lower lateral aspect of leg were considered for coverage with reverse sural flap. Demographic data including age and gender, comorbidities, smoking history, etiology of defect, location of defect, flap size (area cm^2= maximum width cm × maximum length cm) and underlying bony pathology in case of trauma were noted. Modifications performed in cases for harvesting of sural artery flap were also noted. Complications (venous congestion, partial flap necrosis, and complete flap necrosis and flap dehiscence) observed were calculated in terms of percentage. Total duration of operative procedure was noted in terms of minutes from start if incision to complete inset of flap was noted. Percentage of wound healed at 14^{th} post-operative day was also reviewed.

Surgical Technique

After wound care , sural artery flap was designed for coverage of the defect. Pre-operatively, hand held Doppler was used to locate the perforator. Patient was positioned in prone position and under tourniquet control, debridement of the defect with freshening of wound margin was performed. Defect was evaluated and flap was designed accordingly employing various modifications. Various modification executed during study were delaying of reverse artery flap, extended reverse sural artery flap with gastrocnemius muscle cuff, extended reverse sural artery flap along with only mesentery of neurovascular pedicle, exteriorization of the pedicle, islanded reverse sural flap, reverse sural artery flap with skin paddle, nerve sparing reverse sural flap and proximally based sural artery flap. Surgical technique employed was according to the modification used. However, as a standard, neurovascular axis was marked by line joining midpoint of prominent part of lateral malleolus and tendoachilles to the midpoint of popliteal crease. Perforators were located along this line usually at 5cm and 7cm, however, in certain cases of reverse sural artery flap where there was scarring in lower perforator zones, flap was based on proximal perforator at even 10cm and 15 cm along with delaying and extended flap. Depending upon the arc of rotation, pivot point and perforator location, wound template was used to mark the size of flap. Flap dissection started with identification and division of sural nerve and artery and lesser saphenous vein at distal part of flap and must be included within flap harvest. Flap dissection is carried out in

sub fascial plane in standard flap, however, in extended flap; neurovascular pedicle lies deep between two heads of gastrocnemius must be incorporated in the flap either along with mesentery or with 1cm gastrocnemius muscle cuff. Fascia was sutured to skin flap to avoid shearing forces or detachment of vascular pedicle. As the dissection progressed, musculocutaneous perforators to gastrocnemius muscle and fasciocutaneous perforators of peroneal axis were divided up to the level of pivot point. Pedicle width of at least 4 cm was maintained. Flap was islanded either by tunneling through the subcutaneous tunnel or by exteriorization of pedicle and coverage with skin graft if the tunnel was tight. In certain cases, the reverse sural artery flap was also harvested with skin paddle where the skin paddle was used to cover the defect or where the neurovascular axis in within zone of trauma. In this case, second stage of division and in setting was done after 3 weeks. In cases of delay, second surgery was performed after 10 days after delay procedure, Nerve sparing reverse sural artery flap technique was employed to preserve the sensation of lateral aspect of foot. Proximally based sural artery flap was used to cover defects around knee and proximal one third of leg. Vascularity of flap was assessed after tourniquet release. The flap was inset at the defect site and splintage was done to restrict the movements. Donor area was skin grafted. Patients were advised standard scar therapy. Follow up was done at one month, 3 month and 6 month

Results

A total of 35 cases of lower limb soft tissue defects were dealt with sural artery flap. It included 28 males and 7 females. Mean age of patients is 31.62±13.93 years. Among 30 patients, 5 patients were diabetic, 3 were hypertensive and 6 were smokers. 22 cases presented with bony involvement. Heel area was involved in 7 cases. Defects at lower third of leg were covered in 5 cases. Dorsum of foot was covered in 5 cases. Defects at medial aspect of knee were covered in 3 cases. Ankle was site of defect in 14 cases (Table-1).

Road traffic accident was the most common etiology of these soft tissue defects with 24 cases, followed by diabetic foot in 3 cases, chronic ulcers in 4 cases, tumor in 2 cases and post burn contracture in 2 case (figure 1).

Proximally based sural artery flap was done in 4 cases. Flap was delayed in 15 cases, in which 8 were islanded while 7 were with skin paddle. Distally based reverse sural artery flap was done in 16 cases in which 3 were nerve sparing, 8 were islanded while 5 were peninsular. A bar chart in figure 2 represents the modifications of sural artery flap.

Table 3: *Table Representing Demographic Details, Frequency of Co-morbidities, Bony Involvement and Defect Site*

Demographic variable	Frequency (%)
Age (Mean±SD)	31.62±13.93 years
Gender	
Male	28 (80%)
Female	7 20%)
Comorbidity	
None	21 (60%)
Smoking	6 (17.1%)
Diabetic	5 (14.3%)
Hypertensive	3 (8.6%)
Bony involvement	22 (62.9%)
Site of defect	
Medial aspect of knee	3 (8.6%)
Distal one third of leg	5 (14.3%)
Dorsum of foot	5 (14.3%)
Posterior aspect of heelankle	8 (22.9%)
	14 (40%)

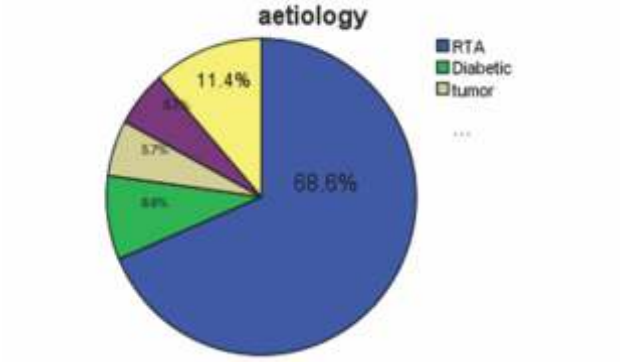

Figure 1:- *A Pie Chart Showing Distribution of Aetiology of Lower Limb Defects*

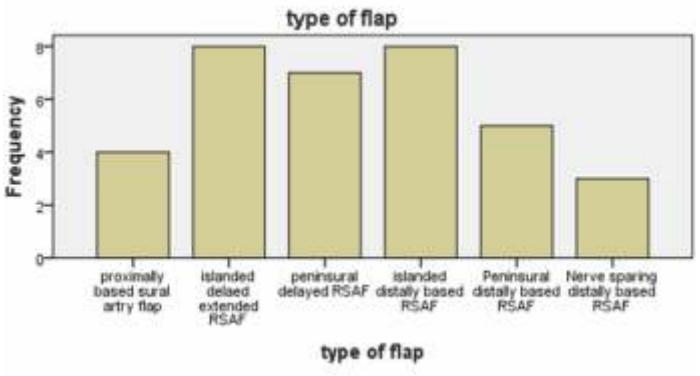

Figure 2:-A Bar chart showing modifications of sural artery flap

Mean flap size was131.48±29.46cm^2. Mean operative time was 79.71±18.78 minutes. Venous congestion was observed in 3 cases which was managed conservatively with elevation and removing stitches. 1 cases showed dehiscence which healed conservatively. Partial flap necrosis was observed in 2 cases. Only distal most parts showed necrosis and that was limited to couple of centimeter strip area. The resulting defects in these cases healed by secondary intention. None of the flap underwent complete flap necrosis. (Table-2)

Table 2: *Frequency and Percentage of Patients with Respect to Complications*

Outcomes	
Complications (14%)	
Partial Flap Necrosis	2 (5.6%)
Complete flap necrosis	0 (0.0%)
Dehiscence	1 (2.8%)
Venous congestion	2 (5.6%)
Size of flap (cm^2)	131.48 ±29.46cm^2
Operative time(minutes)	79.71 ±18.78min
Percentage of wound healing	97 % ± 3

All data was analyzed using SPSS Version 21. Quantitative data (age, size of flap , operative time) was presented as mean and standard deviation. Qualitative data was presented as percentage and frequency.

Discussion

This study provides significant evidence that the sural artery flap is a safe and a practical option for reconstruction of defects of lower third of leg, knee, ankle and dorsum of foot proximal to toes. The results show various modifications of flap that increases the flap survival and lowers the complication rate.

Road traffic accident is the commonest cause of limb trauma in South Asia.[4,5] So far is presented in our study that majority of defects (68 %) are due to road side accidents. This also includes spoke wheel injury and degloving injury with exposed extensor tendons. Other causes of defects of lower leg are chronic ulcers, malignancy (melanoma, marjolin ulcer), chronic ulcers, diabetic foot and defects after post burn contracture release are represented in figure 1.Same distribution of etiology is observed in a study by Patil B6.

Although heel defect of small to moderate size is the most commonly treated site with reverse sural artery flap,[7,8,9] the larger defects around ankle, lower third of leg, dorsum of foot and sole presents true challenge for coverage with this technique. Free flap is considered as gold standard for such defects. But this study shows employing different modifications can boost its reliability even in case of larger flap and distant defect. Average size of flap harvested in this study is 131.48± 29.46cm^2. This is closer to average size of flap (148.10 ±59.54cm^2) mentioned in a series of extended reverse sural artery flap published by Anoop C et al.[10] This result is also in consistent with that noticed in a study by Kneser et al in case of delay of flap[11]. However, mean flap dimension of classical flap is 8.8 ×5.6 cm (49.2cm^2) mentioned in studies available in literature.[12] So modifying the flap can enhance its vascularity and extension.

Proximal extension of reverse sural artery flap is not predictable in terms of vascularity.[13,14] For coverage of larger defects, several modifications have been presented in literature to make it more reliable. Extended flap, Delaying of extended flap, pedicle wider than 3 cm, and harvesting of midline gastrocnemius provide longer arc of rotation and larger dimension of flap to cover larger defects at difficult sites.[15,16] A systemic analysis of modifications of reverse sural artery flap to boost its reliability by Schmidt et al showed favorable results of modifications in terms of complications, however, comparison of different modifications did not yield any significant difference.[12]

In an article by Yousaf M Amin et al, it is mentioned combination of delay and harvest of midline gastrocnemius cuff for islanded extended reverse sural artery flap is mentioned to provide extended coverage with fewer complications.[5] (In this series, 8 cases were performed in this fashion with only 1 case having partial necrosis. Another trick to cover the large defect of ankle is to harvest the flap as a peninsular flap (flap with cutaneous pedicle). At time of second stage of division and in setting, the skin paddle will provide the tissue coverage of remaining part of the defect. A study by Sheraz M et al discussed the increased reliability of flap with lesser complications by raising with cutaneous pedicle.[17] In this study, five patients having defects of anterior aspect of ankle to the malleolus were covered in this fashion, one representative case is shown in figure 3.

This research highlights the cases where line of lower perforators is within the zone of scarring but extended delayed flap was harvested for coverage based on proximal perforators that were dissected and assessed per-operatively. Figure 4 illustrates the representative case. This is a novel technique to use this flap as an

alternative to free tissue transfer.

Figure 3: *Trauma leading to open fracture of proximal metatarsals and ankle joint with soft tissue defect* ***(A)*** *extensive wound on dorsum of foot and ankle of 15 × 10 cm* ***(B)*** *Delayed extended reverse sural artery flap with skin paddle was used for coverage.* ***(C)*** *In second stage, the skin paddle was used for coverage of lateral part of remaining wound* ***(D)*** *Six moth follow up with future plan of debulking of flap.*

Figure 4:- *Road traffic accident leading to exposed lateral malleolus along with fracture.* ***(A)*** *There is scarring in area of lower peroneal perforator axis line. Extended reverse sural artery was designed based on a perforator at 15 cm.* ***(B)*** *Islanded Extended reverse sural artery flap harvested with cuff of gastrocnemius muscle* ***(C)*** *100 % flap survival on 14th postoperative day* ***(D)*** *6 month follow up*

Figure 5 :- ***(A)*** *Wound on medial aspect of knee of 9×14 cm² with open knee joint and friction burn* ***(B)*** *Islanded proximally based sural artery flap harvested for coverage with rectus femoris tendon repair* ***(C)*** *100% Flap survival at 14th post operative day* ***(D)*** *6 month follow up.*

Three cases of nerve sparing distally based sural fasciocutaneous flap were performed without any complication and preservation of sensation of lateral aspect of foot. Though the study has been published about the reliability of this flap as Aydin et al, still this entity needs more research[18]. Another unique utility of sural artery flap is proximally based sural artery flap for knee defects. Manav P et al performed a retrospective study showing good outcomes of this regional flap as a coverage option.[22] Gastrocnemius muscle flap is commonly used option for coverage of knee defects but for larger defects, free tissue transfer is required. However, proximally based fasciocutaneous sural artery flap is a good alternative when the defect is larger and secondary surgery is required for orthopedic intervention. Figure 5 exemplifies the defect treated in this manner.

Several studies showed different complication rate ranging from 5% to 35%.[13,16,19] Baumeister et al published a data which showed complication rate for partial flap necrosis of 35 %.[20] In our study, partial flap necrosis is 5.6 % which shows proper planning, execution and post-operative care are also important factors for flap

survival. Complete or near complete flap necrosis is rare as shown in a study by Kneser et al.[11] Same result is inferred in this article. Venous congestion is the most common complication (75.3%) encountered[12]. Kristoffer B et al discussed in his article that reverse sural artery flap salvage rate had been improved from 50 % to 93% with modification of increasing the pedicle width up to 4 cm or using cutaneous pedicle. This modification reduced the rate of using leech therapy for venous congestion from 42% to 0%.[21] In this series, we employed the same modification and had only 1 Venous congestion which was managed conservatively Complication rate has been significantly reduced in last ten years as a result of evolution of various modifications Overall complication rate in this study is 14%. A systemic analysis by Schmidt K etal proved that modified reverse sural artery flap has statistically significant improvement in complication rate as compared to classical fasciocutaneous flap.[12]

Different factors play role in survival of a large flap which are patient's co morbidities (diabetes, hypertension, peripheral vascular disease), smoking, tight tunnel, inadequate flap design and kinking of pedicle.[23] This study demonstrates proper planning and execution can improve flap survival in spite of having co-morbidities.

In this era of covid-19 infection, less operative time and shorter hospital stay is a blessing to deal with such complex defects. Mean operative time in this analysis is 79.71±18.78 minutes which is significantly shorter than for free tissue transfer .In an analysis performed on free flap reconstruction after lower limb trauma by Alam M etal shows mean operative time of 439±163 minutes which requires more oxygen consumption, greater surgical stress and increased chances of post-operative ICU care.[24] In another study by J M Serletti et al, mean operative time for free flap is 7.8 hour which is quite longer.[25] In contrast to this, in a study by Anoop C etal, average duration of surgery was 121.29 ±31.6 minutes and average time to raise flap was just 34.2±9.4 minutes consistent with our results.[10] It is observed in this setting of pandemic, where there is need to reserve the resources, this coverage option for technically difficult defects of lower extremity provides an excellent alternative to free tissue transfer.

Although, this flap may need one or more stages to achieve optimum results but still in centers where there is lack of microsurgical expertise and logistics, this modality proves to be a reliable option with low complication rate. Shorter operative time leads to conservation of resources making sural artery flap a versatile and favorable option in this era of covid-19 infection.

Conclusion

Sural artery flap has always been an excellent choice for reconstruction of defects of lower third of leg of moderate size. However, with modifying this flap, this flap provides coverage of technically difficult, larger defects of lower leg defects. Thus, sural artery flap is an answer for soft tissue coverage of lower limb defects as a reliable alternate to free tissue transfer.

Conflict of interest

None

References

1. Follmar KE, Baccarani A, Baumeister SP, Levin LS, Erdmann D. The distally based sural flap. PlastReconstr Surg. 2007; 119(6):138e-148e.
2. Masquelet AC, Romana MC, Wolf G. Skin island flaps supplied by the vascular axis of the sensitive superficial nerves: anatomic study and clinical experience in the leg. PlastReconstr Surg. 1992;89(6):1115-21.
3. Schaverien M, Saint-Cyr M. Perforators of the lower leg: analysis of perforator locations and clinical application for prediled perforator flaps. PlastReconstr Surg. 2008; 1(122):161-170
4. Dandona R, Kumar GA, Ameer MA, Ahmed GM, Dandona L. Incidence and burden of road traffic injuries in urban India. InjPrev 2008;14:354–9.
5. Amin Yousaf M, Al-abidinM,Khalid K. Extended islanded reverse sural artery flap for staged reconstruction of foot defects proximal to toes. Journal of the College of Physician and Surgeons Pakistan.2018;28:126-128.
6. PatilB,Wahegaonkar C. Extended reverse sural artery pedicle flap: a versatile and reproducible option for coverage of ankle and foot defects. International Journal of Research in Medical Sciences.2019; 7(3):866.
7. Ayyappan T, Chadha A. Super sural neurofasciocutaneous flaps in acute traumatic heel reconstructions. PlastReconstrSurg 2002;109:2307–13.
8. Hyakusoku H, Tonegawa H, Fumiiri M. Heel coverage with a T-shaped distally based sural island fasciocutaneous flap. PlastReconstr Surg. 1994;93:872–6.
9. Mak KH. Distally based sural neurocutaneous flaps for ankle and heel ulcers. Hong Kong Med J 2001; 7(3):291–5.
10. Anoop C Dhamangaonkar, Hemant S Patankar. Reverse sural fasciocutaneous flap with a cutaneous pedicle to cover distal lower limb soft tissue defects: experience of 109 clinical cases. J Orthop Traumatol. 2014 Sep; 15(3):225-9.

11. Kneser U, Bach AD, Polykandriotis E, Kopp J, Horch RE. Delayed reverse sural flap for staged reconstruction of the foot and lower leg. PlastReconstr Surg. 2005; 116(7):1910-7.
12. Schmidt K, Jakubietz M, Meffert R. The reverse sural artery flap- How do modifications boost its reliability? A systematic analysis of the literature. JPRAS Open. 2020 Aug 1;26:1-7.
13. Nakajima H, Imanishi N, Fukuzumi S, Minabe T, Aiso S, Fujino T. Accompanying arteries of the cutaneous veins and cutaneous nerves in the extremities: anatomical study and a concept of the venoadipofascial and/or neuroadipofascialpedicled fasciocutaneous flap. PlastReconstr Surg. 1998;102(3):779-91.
14. Nakajima H, Imanishi N, Fukuzumi S, Minabe T, Fukui Y, Miyasaka T, et al. Accompanying arteries of the lesser saphenous vein and sural nerve: anatomic study and its clinical applications. PlastReconstr Surg. 1999; 103(1):104-20.
15. Karacalar A, Idil O, DemirA, Güneren E, Simşek T, Ozcan M. Delay in neurovenous flaps: experimental and clinical experience. Ann Plast Surg. 2004; 53(5): 481-7.
16. Al-Qattan MM. A modified technique for harvesting the reverse sural artery flap from the upper part of the leg: inclusion of a gastrocnemius muscle "cuff" around the sural pedicle. Ann Plast Surg. 2001;47(3):269-74.
17. Sheraz M, Nazir U, HussianH.Non- islanded distally based sural artery flap: A reliable solution for an unreliable flap.Journal of the College of Physicians and Surgeon.2016;26(4): 310-314.
18. Aydin OE et al. Nerve sparing-distally based sural flap. Microsurgery. 2011; 4(31):276-280.
19. Almeida MF, da Costa PR, Okawa RY. Reverse-flow island sural flap. PlastReconstrSurg 2002; 109(02): 583–591.
20. Baumeister SP, Spierer R, ErdmannD, Sweis R, Levin LS, GermannGK. A realistic complication analysis of 70 sural artery flaps in a multimorbid patient group. PlastReconstrSurg 2003;112(01):129–140
21. Kristoffer B Sugg, Timothy A Schaub, Matthew J Concannon. The Reverse Superficial Sural Artery Flap Revisited for Complex Lower Extremity and Foot Reconstruction. PlastReconstrSurg Glob Open. 2015 Sep 22;3.
22. Manav P Suri , M T Friji, Quazi G Ahmad, Prabha S Yadav. Utility of proximally based sural artery flap for lower thigh and knee defects. Annals of Plastic Surgery 2010 Apr;64(4):462-5.
23. Severo AL, Scorsatto C, Valente EB, Lech OL. Retalhos para reconstrução de perdasmusculocutâneasemmembrosinferiores: análise de 18 casos. Rev Bras Ortop 2004; 39(10):578–589
24. Mehmood M , Shahid S, Ubaid M. Free flap reconstruction after lower limb trauma — outcome analysis using National Surgical Quality Improvement Programme (NSQIP) parameters. Journal of The Pakistan Medical Association.2020;70.
25. J M Serlettietal. Factors affecting outcome in free-tissue transfer in the elderly. PlastReconstr Surg. 2000.