International Journal of Orthopaedics Sciences

E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2022; 8(1): 715-721

www.orthopaper.com
Received: 05-01-2022
Accepted: 07-02-2022

Dr. Vikash Agarwala
Department of Orthopaedics, Silchar Medical College, Silchar, Assam, India

Dr. Veerender Dev
Department of Orthopaedics, Silchar Medical College, Silchar, Assam, India

Dr. Tridip Bharali
Department of Orthopaedics, Silchar Medical College, Silchar, Assam, India

Corresponding Author:
Dr. Veerender Dev
Department of Orthopaedics, Silchar Medical College, Silchar, Assam, India

Soft tissue reconstruction using fasciocutaneous flaps in compound fracture tibia: A case series

Dr. Vikash Agarwala, Dr. Veerender Dev and Dr. Tridip Bharali

DOI: https://doi.org/10.22271/ortho.2022.v8.i1j.3089

Abstract
Objective: To study the role fasciocutaneous flap as a method of soft-tissue reconstruction in open tibial fractures soft-tissue defect and to compare their outcome when used as early coverage with that of delayed coverage.
Materials and Methods: A total of 30 patients with open tibial fractures (type IIIB) were subjected to fasciocutaneous flap for the soft-tissue defect. Patients were divided into two groups based on the timing of soft-tissue reconstruction comprising of 15 patients in each group. Group I the early group (0-7 days) and group II delayed group (8-30 days).
Results: Road traffic accidents accounted for the majority of fractures with 77.7% and 60% in group I and group II. The right leg was involved in 20 patients (66.7%) and left leg in 10 patients (33.33%). Middle one-third of the leg being the predominant site of wound defect 66.7% and 60% in group I and group II respectively. 66.7% of superficial infection was found with the delayed closure (group II) and 46% with early closure (group II). 26.7% of deep bony infection was found to be with the delayed closure and 20% with early closure. 80% of flap survived completely in group I while 73.3% flap survived in group II. In group I the time to union was between 13 weeks and 25 weeks accounting for 73.3% of the cases and in group II the time to union was between 26 weeks and 52 weeks, which accounted for 80% of the cases. The average hospital stay was 13.4 days in group I with 80% ranging in between 10 days and 20 days and in group II the average stay was 22.8 days with 53.3% ranging from 21 days to 30 days.
Conclusion: The goals of soft tissue coverage in open fractures are to achieve a safe and early durable coverage, avoid nosocomial infection and optimize the healing and facilitate the future reconstruction.

Keywords: Delayed closure, early closure, fasciocutaneous flap, open fracture

Introduction
In todays mechanise world with compulsive urge of doing things speedily resulting into increased conflict of man and machine with high velocity trauma leading to complex fracture personality of bone and also severe injury to the soft tissue. Most commonly the young adults are victims of the two wheelers and it is the tibia which is bearing the burn of it. Interestingly tibia being a subcutaneous bone with poor muscle coverage more so in distal one third becomes challenging task for treating team in dealing two things one being the complex fracture and other being the soft tissue reconstruction.
Keeping the bone exposed for a prolonged time lands up into dead bone and complicates the complex fracture. The earlier we cover the bone the better is the outcome. In our experience most of the problems can be solved. 70 to 80 % of soft tissue reconstruction is possible by split thickness graft and local fasciocutaneous flaps which is essentially not a complex surgery and can be performed by orthopaedic surgeon in an average set up. However in certain situations free flaps or cross legged flaps are necessary which comes under the domain of plastic surgeon. Basic understanding of blood circulation of fasciocutaneous flaps by perforators and adhering to certain basic principle is the key to success.
Open fractures of the tibia have a high incidence of infection and malunion. Formerly, the treatment of severe lower leg injuries often land up in primary amputation. Developments in the field of osteosynthesis and reconstructive techniques have led to new treatment possibilities. Early fracture stabilization is essential and can be achieved by means of external fixation, plate and screws, and reamed or unreamed tibial nails. Combined with stabilization, a thorough debridement is essential for further ss.

Principles of Treatment

Fasciocutaneous flap was raised as superiorly based (proximally), inferiorly based (distally) and transversely based flap. These flaps had length to width ratio as great as 3:1 (known as ponten superflaps). Donor site from where flap was raised secondary defect was covered by SSG harvested from thigh region. The limb was immobilised with pop slab and received IV antibiotic and graft dressing was done on post op day 5.

Anatomy and Physiology

The anatomical basis of the fasciocutaneous flap is based on the fasciocutaneous perforators which reach the skin to supply it. At the level of the fascia, there are prefascial and subfascial plexuses and, more superficially, the subdermal and subcutaneous plexuses. These plexuses are supplied by arteries that enter the deep fascia through an underlying muscle (musculocutaneous perforators), through the septum between muscles (septocutaneous branches), or a direct cutaneous branch, between the subfascial and suprafascial plexus, the later one is the most developed. On the contrary, the vessels of the suprafascial plexus have a close relationship with the collagen fibers of the fascia. According to this, the dissection of the subfascial plane to the muscle is more accessible than a dissection of the suprafascial plane.

The fasciocutaneous system is not homogeny, but it varies according to the anatomical area of the body. Anatomical research by Cormack and Lamberty, as well as the clinical application of Pontén and Tolhurst et al., have demonstrated that the septocutaneous vessels have a central role in the suprafascial plexus at the level of the extremities, while at the level of the trunk the musculocutaneous perforators are the main source.

Classifications

Cormack and Lamberty have classified fasciocutaneous flaps into four types based on vascular anatomy.

Type A: Multiple fasciocutaneous perforators entering at the base of the flap supplied the flap. The flap can be placed proximally or distally.

Type B: A single fasciocutaneous perforator supplied the flap. This flap may be isolated as an island flap or used as a free flap.

Type C: Multiple small perforators from the main artery reach the skin through a fascial septum. The main artery is included with the flap. It can be based proximally, distally, or as a free flap.

Type D: A compound flap, similar to type C but including a portion of adjacent muscle and bone.

Indications

The harvesting of fasciocutaneous flaps is quick and easy with enough practice. The indications are based on its advantages.

These flaps are reliable, thin, and easily mobilized, coming from many potential donor sites. Most of them preserve the main arterial axis. Unlike muscle flaps, the functional sequelae of the donor site are minimal. Although the fasciocutaneous flaps were considered to be not as resistant to infection as muscle flaps because fat and fascia are less vascularized than muscle, several studies concluded that fasciocutaneous flaps offer a comparable efficacy to the muscle flaps for infection treatment. Moreover, fasciocutaneous flaps enable revision for orthopaedic procedures and limit the need for secondary skin grafting. Fasciocutaneous flaps are preferred in reconstructing areas in which the skin or mucosa at the wound is thin; for example, the lower leg, dorsum of the hand, nasal lining, and oropharynx. Similar to muscle flaps, fasciocutaneous flaps provide large blocks of tissue for defect reconstruction without the need for the prior delay but are limited by the arc of rotation of the vascular pedicle, unless transferred as a free flap. They are not recommended in case of a deep cavity where muscle flap has an indication.

Fasciocutaneous flaps can be harvested in four different variants according to the tissue included

1. Peninsular Fasciocutaneous Flap: The adipofascial cutaneous unit is harvested, leaving the base of the flap as a hinge where it will be rotated. The peninsular flap is utilized as a rotation flap, and its possibilities of coverage are limited. Moreover, rotation at its base produces bulkiness or a dog-hear deformity, which sometimes need a secondary procedure to correct it.
2. Island Fasciocutaneous Flap with an Adipofascial Pedicle: This variant is characterized by a vascular pedicle whose length confers to the flap, an arc of rotation that defines its possibilities. The fasciocutaneous unit is harvested according to the size of the defect to be covered. The pedicle is formed by an adipofascial strip or by an identifiable vascular pedicle.
3. Adipofascial Flap: This variant includes the fascial plane along with a hypodermic layer.
4. Fascial Flap: Its main indication is related to coverage of tendons to provide a gliding surface.

Fasciocutaneous flap of the legs

The leg was the first region in which the fasciocutaneous flap proved of great value. Several fasciocutaneous flaps have been applied to reconstruct a coverage deficit of the leg. However, preoperative planning is crucial since the stiffness of the fascia can difficult the insetting of the flap on the defect.

Flaps can be harvested at the posterior, lateral, or medial aspect of the leg and designed as proximally or distally based according to the point of the pivot, in the case of distally based flaps, a higher risk of venous congestion exits. This latter complication can be overcome by making anastomosis of the superficial vein of the flap to a superficial vein in the recipient site.

Vascularization

Cutaneous and neurocutaneous branches are few in numbers. At the posterior aspect of the leg, in the midline, the sural artery after been in the suprafascial plane vascularized the skin. Musculocutaneous perforants are more numerous at the proximal third of the leg, going through the medial and lateral gastrocnemius muscles.

On the other hand, septocutaneous arteries are found mainly in the middle and distal third of the leg. They come from one of the three main arterial axes of the leg (anterior or posterior tibial artery and peroneal artery).

The venous return goes directly for the accompanying veins of the arterial supply.

Fasciocutaneous flaps proximally based

The base of the flap should provide enough blood flow to allow to survive the flap. The base of the flap is not designed according to a length/width ratio; instead is designed to a defined pedicle. Based on this, the pedicle can be narrowed at

the base until a true island flap can be harvested.

- **Saphenous Flap**

Acland et al. described saphenous flap; this flap is based on the saphenous artery, which pierces the aponeurosis roof of the adductor canal within 2 cm of its origin and then runs down between the sartorius and vastus medialis muscles and the adductor tendon for a distance of 12 to 15 cm. It then gives off one to four important cutaneous branches to supply a large area of skin medially above the knee. The terminal (distal) saphenous artery passes between the sartorius and gracilis tendons and is distributed to the skin of the upper and medial portions of the leg below the knee.

The flap dimensions can achieve 8 to 10 cm in width and 30 cm in length (10 cm above and 20 cm below the knee). The proximal third of the tibia can be covered with the distal part of the flap. However, in case of knee deficit coverage, the flap has to be harvested more proximally, and the sartorius has to be divided between raising the flap.

- **Medial fasciocutaneous Flap**

The flap is nourished by the musculocutaneous perforators of the head of the medial gastrocnemius. The anterior border of the flap is a line posterior to the medial edge of the tibia; the distal limit should not extend from a line that is located 5 cm proximal to the medial malleolus and posteriorly the flap should be designed at the posteromedial line.

The flap is useful to cover the anterior aspect of the knee, and the proximal and middle third of the leg.

- **Lateral Fasciocutaneous Flap**

As its medial counterpart, the lateral flap is nourished by the musculocutaneous perforators of the head of the lateral gastrocnemius. The anterior limit of the flap is 2 cm posterior to the posterior edge of the fibula, the posterior limit is the medial line, and the distal limit should not exceed the 10 cm proximal to the lateral malleolus tip.

- **Anterolateral Fasciocutaneous Flap**

This flap is nourished by the musculocutaneous perforators of the tibial anterior and peroneal arteries. It should be designed with an anterior limit 2 cm posterior to the tibial crest, the posterior limit is posterior to the fibula, and the distal limit is located 5 cm proximal to the tip of the lateral malleolus.

- **Posterior Fasciocutaneous Flap**

Described by Walton and Bunkis as a new cutaneous free flap, the blood supply to the skin of the posterior leg is derived from two sources: 1) perforating arteries that arise from the popliteal and posterior tibial arteries and 2) axial arteries originating from the popliteal, sural, and geniculate arteries that course either above or below the deep fascia. The flap can be raised from the popliteal fold proximally until the union between the middle and distal third of the leg distally, and the medial-lateral limits could reach the axial medial or lateral midline.

Fasciocutaneous flaps distally based

This kind of flap is vascularized by the septocutanous perforators located at the medial and lateral borders of the Aquiles tendon. These perforators come from the posterior tibial and the peroneal arteries.

The flap can be raised from the popliteal fossa proximally, and distally based can be designed in three different ways: 1) based on the perforators of the posterior tibial artery leaving 3 to 4 cm width base. The distal dissection should not exceed the 10 cm proximal to the tip of the malleolus medial. 2) based on the perforators of the perineal artery, with a pedicle of 3-4 cm width base. The distal limit of the dissection should not exceed beyond the 13 cm proximal to the tip of the lateral malleolus. Finally, it could be raised 3) based on both pedicles for which it should have a broad base to include them.

- **Sural Fasciocutaneous Flap**

This is a variant of the distally based fasciocutaneous flaps. This flap is based on the vascularization provided by the artery that runs along with the sural nerve.

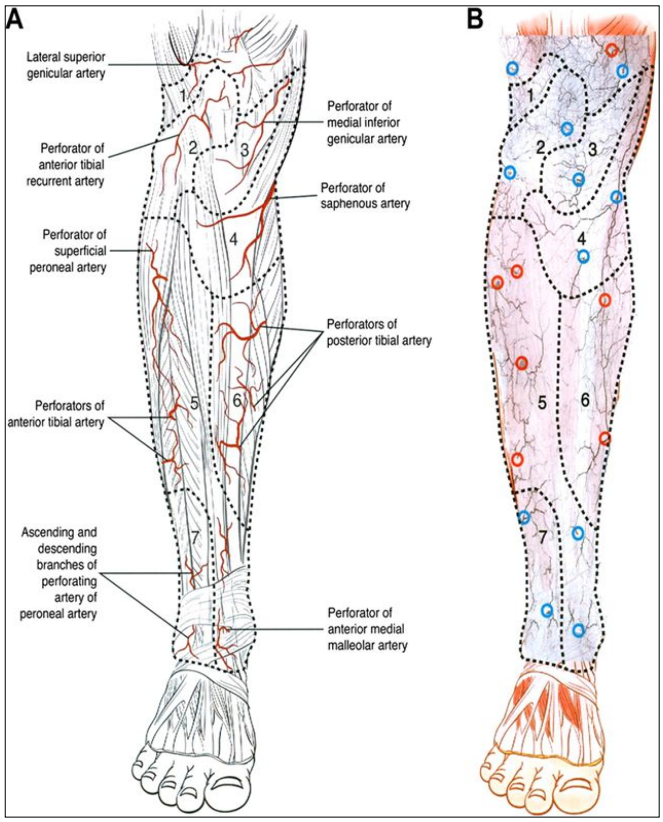


Fig 1: Perforators of leg

Contraindications

Smoking has a considerable negative repercussion on the microcirculation. It is considered a relative contraindication to this procedure. If smoking cessation cannot be obtained, a better vascular flap (muscle flap) should be considered. In all cases, patients must be informed of the risks involved.

In the case of diabetes or poor vascular status, the risk of failure is also higher. Preoperative evaluation can also detect soft tissue lesions or insufficiency of vascularization: sequelae of previous trauma, scars, concomitant traumatic injuries, poor vascular state. A computed tomography angiography is useful in cases of major trauma and arterial disease, to explore the vessels supplying the fascia and to evaluate the recipient site of a possible free flap.

They may not be used in places where deep defects are found. In this case, bulky flaps as muscle flaps are preferred. Sometimes there are size limitations, and donor sites may require skin graft closure.

Equipment

No special surgical equipment is required for performing fasciocutaneous flaps. This procedure can be done with a standard, minor operations surgical set.

Equipment needed is as follows

Preoperatively

- Alcohol solution or pad
- Surgical marker
- Local anesthesia
- Topical antiseptics, such as broad-spectrum chlorhexidine or povidone-iodine
- Surgical drape

Intraoperatively

- Scalpel (#15 blade)
- Forceps (with teeth)
- Shea scissors (or other dissecting scissors)
- Iris scissors, preferably serrated
- Gauze
- Electrocoagulation/electrocautery device
- Skin hooks
- Needle driver
- Normal saline (keep tissue clean and moist)
- Suture (absorbable and nonabsorbable)

Postoperatively

- Petrolatum
- Non-stick dressing material
- Gauze
- Surgical tape

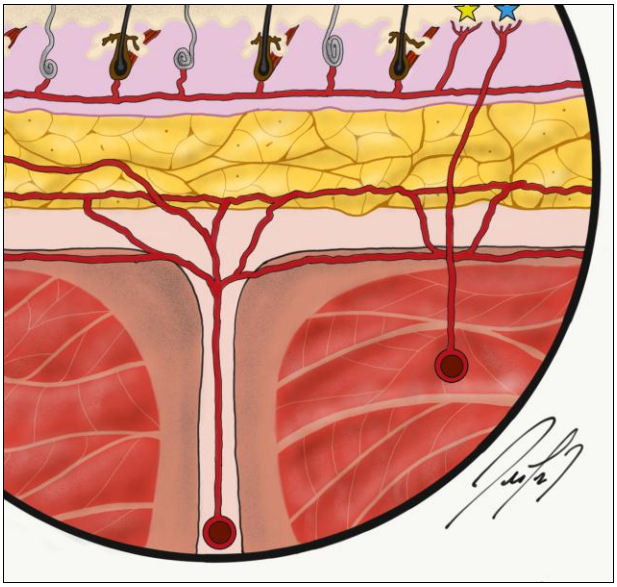


Fig 1: Green star stands for a septocutaneous perforator. Yellow star for a direct cutaneous perforator. Blue star for a musculocutaneous perforator.

Patients and methods

30 patients were treated with fasciocutaneous flap following a traumatic open fracture of the lower leg. All patients were treated at Silchar Medical College and Hospital. Data was gathered by reviewing patient charts, operative reports, and electronic patient record.

In our study, patients were treated because of posttraumatic soft-tissue defects and, therefore, insufficient fracture coverage (primary reconstruction). In the case of primary reconstruction, we also compared the results regarding the timing of the operation: patients treated within 72 h after the trauma versus patients treated after 72 h. Outcome was assessed according to the number of postoperative complications (infections, hematoma or hemorrhage, and dehiscence), partial and complete flap failures, secondary amputations and revisions, the length of hospital stay, and regaining of preoperative mobility

Case 1

10 Days After Surgery

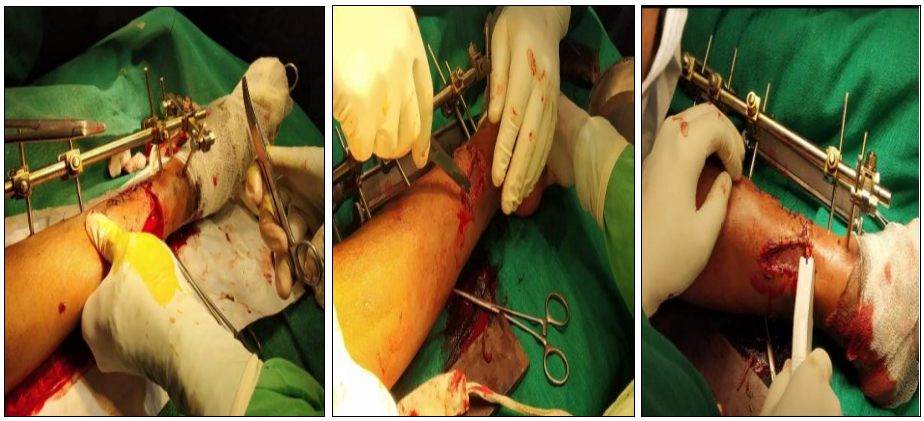
Case 2

Photograph after healing

Patient presenting for follow up in OPD

Fig 2: Above mentioned patient is post operated case of ilizarov ring application after presenting with infective non union of tibia.

Case 3



Intraoperative photograph of fasciocutaneous flap closure

Case 4

Fig 3: Wound photograph before and after healing

Results

As can be expected, free flaps are more frequently used in the treatment of distal third fractures of the tibia because of the limited possibilities for local reconstruction. In the entire study group, 8 patients developed a postoperative complication, which consisted of hematoma (8%), haemorrhage (2%), flap dehiscence (4%), or infection (3%). 2 patients developed a partial flap failure, after which the necrotic skin was resected. In three patients, mobility could not be assessed because of departure to their home country shortly after discharge from the hospital. The median length of hospital stay was 16 days (range, 4–128 days).

Primary reconstruction

In 30 patients, a primary reconstruction was performed. Seven patients (20%) had a defect located at the proximal third of the tibia, seven patients (20%) at the middle third, and 21 patients (60%) at the distal third.

The average duration between the trauma and the operation was 7 days, with a median duration of 11 days (range, 0–176 days). Other patients were operated on after several days because of their initially critical condition. Most of these patients were polytrauma patients with a long intensive care unit stay and initial treatment for other (life-threatening) injuries. Within this group, only 30 patients were diagnosed with just a lower leg injury. After the initial trauma screening, fixation of the fracture was performed, either directly or at a later stage. The fracture was stabilised by means of an external fixator in 15 patients (50%), a plate and screw fixation in patients (31%), and an intramedullary nail in remaining patients.

A hematoma developed in five patients (14%) as a postoperative complication. One patient had a hemorrhage, 3 patients developed an infection, and 1 patient had a dehiscence of the flap. Eventually, two patients underwent a secondary amputation.

Discussion

Much has changed in the treatment of soft-tissue defects after open fractures of the lower leg. The introduction of free flaps provided a virtually unlimited supply of tissue for reconstruction. Early treatment is more widespread and advocated after the introduction of antibiotic prophylaxis and improved techniques for fracture stabilization. Advocates of delayed flap coverage refer to the expansion of the zone of injury and prefer serial debridements before definitive treatment. Distal third wounds of the lower leg especially remain a challenge for the traumatologist surgeon because of the limited possibilities for local muscle and soft tissue transposition. Other studies recommend initial treatment with a vacuum-assisted closure system. These studies describe vacuum-assisted closure being applied either as a bridge to surgery by diminishing the surface area of the wound and inducing tissue granulation or as a definitive treatment in combination with soft tissue reconstruction.

Patients treated with local flaps showed better results on almost every other aspect, but these differences did not appear to be significant. On the other hand, practical experience shows that, in case of large or serious defects, free flaps remain the only possibility for reconstruction, whereas local flaps can be used in less serious or smaller defect. fasciocutaneous flaps can provide a better cosmetic and functional result, especially when related to defect of the distal third tibia.

In our study, we could not find a statistical difference regarding the timing of the operation. Previous, often older, studies show an increase in infection after early primary closure and, therefore, recommend delayed closure. Treatment within 72 h after the trauma in our study did not result in a significant increase in postoperative complications such as infection or flap failure. Other studies show a reduction in the occurrence of postoperative flap infection and other complications after early flap coverage. These patients are assumed to be at a greater risk of developing postoperative complications. Soft tissue coverage was done with fasciocutaneous flaps. These flaps were based on septocutaneous perforators of posterior, anterior tibial and peroneal arteries. Fasciocutaneous flap was raised as superiorly based (proximally), inferiorly based(distally) and transversely based flap. Donor site from where flap was raised secondary defect was covered by SSG harvested from thigh region. The limb was immobilised with pop slab and received IV antibiotic and graft dressing was done on 5.

Conclusion

Patients with large soft-tissue defects of the lower leg after a traumatic open tibial fracture should be initially treated with a local, fasciocutaneous flap whenever possible. If the location or size of the defect makes local reconstruction impossible, free flaps and cross legged remain the only possibility for reconstruction. The use of vacuum-assisted closure to obtain a surface area suitable for a further treatment down the reconstructive ladder has to be considered.

References

1. Patzakis MJ, Wilkins J, Moore TM (1983) Use of antibiotics in open tibial fractures. Clin Orthop 178:31 PubMed Google Scholar.
2. Chittoria R, Mishra SM. Fasciocutaneous flaps in reconstruction of lower extremity: Our experience. Kathmandu Univ Med J (KUMJ) 2004;2:344-8. [PUBMED]
3. Mackenzie DJ, Seyfer AE. Reconstructive surgery lower extremity coverage. In: Mathes SJ, Hentz vr, editors. Plastic Surgery Trunk and Lower Extremity. 2 nd ed. Philadelphia: Saunders Elsevier; 2006. p. 1364.
4. Mess D. Lower extremity trauma principles of evaluation and earlymanagement. In: Cohen M, editor. Mastery of Plastic and Reconstructive Surgery. 1 st ed. New York: Little Brown and company; 1994. p. 1773.
5. Pontén B. The fasciocutaneous flap: Its use in soft tissue defects of the lower leg. Br J Plast Surg 1981;34:215-20.
6. Rajasekaran S, Dheenadhayalan J, Babu JN, Sundararajan SR, Venkatramani H, Sabapathy SR. Immediate primary skin closure in type-III A and B open fractures: Results after a minimum of five years. J Bone Joint Surg Br 2009;91:217-24. [PUBMED]
7. Weitz-Marshall AD, Bosse MJ. Timing of closure of open fractures. J Am Acad Orthop Surg 2002;10:379-84. [PUBMED]
8. Hohmann E, Tetsworth K, Radziejowski MJ, Wiesniewski TF. Comparison of delayed and primary wound closure in the treatment of open tibial fractures. Arch Orthop Trauma Surg 2007;127:131-6.
9. Russell GG, Henderson R, Arnett G. Primary or delayed closure for open tibial fractures. J Bone Joint Surg Br 1990;72:125-8. [PUBMED].
10. Gustilo RB, Merkow RL, Templeman D. The management of open fractures. J Bone Joint Surg Am 1990;72:299-304. [PUBMED].

11. Patzakis MJ, Bains RS, Lee J, Shepherd L, Singer G, Ressler R, *et al*. Prospective, randomized, double-blind study comparing single-agent antibiotic therapy, ciprofloxacin, to combination antibiotic therapy in open fracture wounds. J Orthop Trauma 2000;14:529-33. [PUBMED].
12. DeLong WG Jr, Born CT, Wei SY, Petrik ME, Ponzio R, Schwab CW. Aggressive treatment of 119 open fracture wounds. J Trauma 1999;46:1049-54. [PUBMED].
13. Crowley DJ, Kanakaris NK, Giannoudis PV. Debridement and wound closure of open fractures: The impact of the time factor on infection rates. Injury 2007;38:879-89. [PUBMED]
14. Haque MR, Hamid F, Rahman MM, Haque AM, Khandker MH. Early versus delayed fasciocutaneous flap coverage for type IIIB opentibial shaft fractures comparision of results. Dinajpur Med Coll J 2010;3:76-80.
15. Yazar S, Lin CH, Lin YT, Ulusal AE, Wei FC. Outcome comparison between free muscle and free fasciocutaneous flaps for reconstruction of distal third and ankle traumatic open tibial fractures. Plast Reconstr Surg 2006;117:2468-75. [PUBMED]