Scholars Journal of Applied Medical Sciences
Abbreviated Key Title: Sch J App Med Sci
ISSN 2347-954X (Print) | ISSN 2320-6691 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Surgical Oncology

Effectiveness of Soleus Muscle Flap for The Coverage of Wound in Open Tibia Fracture in The Mid Shaft

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DOI: https://doi.org/10.36347/sjams.2024.v12i10.010 | **Received:** 25.08.2024 | **Accepted:** 07.10.2024 | **Published:** 09.10.2024

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Abstract **Original Research Article**

Introduction: An open fracture of the tibia has been one of the most common long bone injuries. Soleus muscle flap supply can be a remedy for this kind of soft tissue difficulties. The soleus muscle flap's blood supply may help in the construction of a longer, safer, and more functional flap. When the incision is clinically fit for covering, the flaps from the same leg are elevated between 0 and 14 days following the damage. In the majority of these cases, the flaps are covered with a split-thickness skin graft taken from the anterior aspect of the thigh in the same sitting. This can be a great solution.

Aim of the study: The study aimed to assess the effectiveness of soleus muscle flap for the coverage of wound in open tibia fracture in the mid shaft.

Methods: This prospective interventional study aimed to evaluate the outcomes of early coverage using the soleus muscle flap in the management of Gustilo type-IIIB fractures of the mid-shaft tibia. The study followed a quasi-experimental design and was conducted over an 18-month period from January 1, 2010, to June 30, 2011. The research took place in the Department of Orthopaedics and Traumatology at Dhaka Medical College Hospital (DMCH) and the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR) in Dhaka. The study population included all 15 patients admitted to the hospitals with clinical and radiological evidence of open Gustilo type-IIIB fractures of the mid-shaft tibia followed by the inclusion and exclusion criteria. Informed written consent was taken before data collection and confidentiality was maintained. The analysis was done by SPSS version 15.

Result: Among 15 patients most (12) were male, 3 were female. Mean age was 38 ± 12 years. Majority were in 31-45 years. Male female ratio was 4:1. The selected study subjects were predominantly motor driver (26.66%), followed by day labor, housewife, service holder, farmer, and businessman (each was-13.33%), and student was 6.66%. Among 15 patients 93.3% (14) were victims of motor vehicle accidents (MVA) ; right and left sides were affected in 8 and 7 patients respectively. Almost all males (11) & all females (3) were victims of MVA. In this study, comminuted fracture was in 39.96%, Oblique fracture was in 26.64%, Transverse in 19.98%, Segmental and bone loss each was in 6.66%. Bacteriological culture and sensitivity was performed in every case during final wash out before flap surgery. Out of 15 cases, 5 patients yielded no growth. 4 patients were infected with streptococcal infection. Pseudomonas, staphylococcal and E.Coli infection was 2, 3 and 1 respectively. Moreover, five flap surgery was done within 7 days of injury. Most of the flap surgeries were done between 7 to 14 days of injury. Mean time interval between injury and flap surgery was 8.9 ± 2.9 days. In this study mean duration of hospital stay was 24 ± 4.18 days. For most (73.26%) of the cases hospital stay was above 21 days. All the fractures were initially stabilized by external fixator. In case of 9(59.94%) patients IM nail was given after removal of external fixator. Stabilization by long leg full plaster and Ilizarov external fixator each was in 19.98% (3).In most (79.92%) of the cases no additional procedure was needed. One(6.66%) patient required cross leg flap due to >50% flap necrosis .One (6.66%)patient needed STSG due to marginal necrosis and another(6.66%) patient needed resuturing due to flap sagging.Regarding range of movement, knee movement was above 125^0 in 73.26 % (11) patients, ankle dorsiflexion above 10^0 in 59.94%(9) patients and planter flexion above 30^0 in 66.66 % (10) patients. Average knee movement was 127.67^0, ankle dorsiflexion and planter flexion were 12.34^0 & 36.34^0 respectively.

Regarding flap necrosis, 2 (13.32%) patients developed marginal flap or tip necrosis. Out of 2, 1(6.66%) patient required additional procedure. One patient required cross leg flap to cover the defect due to more than 50% flap necrosis. Almost (93.24%) all flaps adhered completely with underlying tissue and wound healed satisfactory. Soft tissue infection developed in 26.64% patients and pin tract infection in 6.66 % cases. Flap sagging occurred in 13.33% & wound break down in 6.66% patient. Subfacial or under flap discharge developed in 46.62 %(7) patients which was treated successfully. So, among the population we found almost 60% to 100% satisfactory result by the procedure. It is quite acceptable outcome. And there is satisfactory outcome in 100% cases where flap coverage done within 7 days.

Conclusion: In most cases, the early wound covering of a Gustilo type-III B fracture of the mid shaft of the tibia with a Soleus muscle flap showed excellent to good result and minimum morbidity. The soleus flap can provide satisfactory soft tissue coverage for the exposed bone in Gustilo type III B fractures of the middle third of the tibia due to its unique vascular pedicle and rich blood supply. If the flap is performed within one week of the injury, a satisfactory result can be achieved.

Keywords: *Soleus muscle flap, Open tibia fracture, Mid-shaft tibia fracture, Wound coverage, Fracture management, Muscle flap reconstruction, Tibia fracture wound healing, Bone and soft tissue repairFlap viability, Post-fracture wound management*

INTRODUCTION

An open tibia fracture has been the most challenging problem of all long bone injuries (Gustilo, 1993). Because of its location, the tibia is exposed to frequent injury and it is the most commonly fractured long bone. Because one third of tibial surface is subcutaneous through out most of its length, open fractures are more common in tibia than in any other major long bone. The blood supply of the tibia is more precarious than that of bone as enclosed by heavy muscles (Whittle, 2008). An open fracture is contaminated, and usually from a high-energy injury which may threatened the limb and occasionally life. The unique anatomy of the tibia with its associated soft tissue and their vulnerability to severe injury produces most of the problem like limb salvage, medium or long term problems with soft tissue cover, infection and union which are all too common and result in serious disability (Gopal *et al.,* 2000). Most orthopaedic surgeons work outside a referral centre and although called on to manage these injuries, with subsequent referral to a department of plastic surgery for delayed soft tissue reconstruction, individually they usually have limited personal experience of the more serious injuries (Gustilo *et al.,* 1990; Gopal *et al.,* 2000). The prevalence of open tibial diaphyseal fractures are 21.9% of open fractures which is the highest prevalence of all open fractures and among them 56.2% fractures are Gustilo III (Court-Brown *et al.,* 2009). In Gustilo type IIIB open fracture extensive injury or loss of soft tissue resulting exposed bone and massive contamination is obvious (Gustilo *et al.,* 1990). The problem is challenging because Gustilo type IIIB fractures are associated with high rates of infection, non union, malunion and amputation (Tornetta III *et al.,* 1993). Early aggressive reconstruction of soft tissue to cover exposed bone significantly reduces the risk of infection, nonunion and subsequent amputation (Caudle & Stern, 1987). In the total management of Gustilo type III B fracture that it is not possible to do primary closure irrespective of early arrival of patient within 6-8 hours of time. The established management of severe open fractures is based on a philosophy of initial wound debridement and lavage, stabilization of the fracture and delayed wound closure (Gustilo *et al.,* 1990). Repeated debridement may be required because of the difficulty of assessing tissue viability. The bone is usually stabilized with an external fixator because of concerns regarding the implantation of metal into a contaminated field. Soft-tissue cover is delayed (not primary closure) to allow for wound swelling and facilitates a second-look procedure to reassess tissue viability. Although widely accepted, this treatment has been challenged, as repeated debridement and delayed closure may lead to additional tissue loss because of desiccation and infection (Hertel *et al.,* 1999; Gopal *et al.,* 2000). The immediate irrigation of the wound and thorough debridement of all necrotic tissue along with early soft tissue coverage is the primary objective in dealing with lower extremity fractures with soft tissue defect (Daecke *et al.,* 2007). Regarding the timing of wound closure 'early soft tissue cover' usually means within 72 hours (Godina, 1986). According to Gustilo, there is no place for primary closure in open fractures irrespective of any type because of increased sepsis and the risk of gas gangrene (Gustilo, 1993). He suggested wound closure in type IIIB fractures within 3-5 days. British Orthopaedic Association and British Association of Plastic Surgeons in there their joint study on management of open fracture, suggested that open tibial fractures should be covered within a maximum 5 days (Court-Brown *et al.,* 1997). But a country like Bangladesh which has a huge population in relation to her total area and resources it is almost impossible for the surgeons to perform wound coverage only within 5 days. Fischer suggested adequate debridement and early assessment of soft tissue defect are necessary so that appropriate soft tissue coverage can be provided within first one to two weeks (Fischer *et al.,* 1991). Accordingly in this study the badly contaminated wounds covered, when judged to be eligible for, within 0-14 days of trauma and in accordance to the just mentioned study has been operationally termed as early or delayed primary closure. Muscles have a rich blood supply with distinct

vascular pedicle which enhances fracture union and the vascular pedicle is often located outside the surgical defect owing to the area of rotation and the length of the muscle. The muscle provides bulk for deep, extensive defects and protective padding for exposed vital structures. It can be manipulated to produce a desired shape or volume. Moreover, well-vascularized muscle is resistant to bacterial inoculation and infection. However, reconstruction using muscle is often an one stage procedure. The reliability and availability of gastrocnemius and soleus muscles make the muscle an excellent alternative means of reconstruction when the method of choice for a particular defect is unavailable or inadequate and negligible morbidity of donor site is observed. (Mathes & Eshima, 1990) The management of lower extremity has evolved over the last-two decades to the point that many extremities that would have required amputation are routinely salvaged (Haq *et al.*, 2009; Kasabian & Karp, 2007; Mareck & Pu, 2004). This is mainly because of better understanding of anatomy and vascular patterns of the areas, resulting in expansion of available choices to cover a wider range of defects. Local options available for soft tissue coverage of leg include muscle, fasciocutaneous and adipofacial flaps (Kasabian & Karp, 2007). Free tissue transfer has become gold standard option for the large complex defects of the lower limb (Mackenzie & Sayfer, 2006; Haq *et al.*, 2009). Amongst the local options, the soleus muscle flap is still a widely used option for coverage of defects of the middle third of the leg (Hallock, 1996). Previous authors have recommended gastrocnemius rotational flaps for the defects over the proximal one third of the tibia, soleus rotational flaps for defects over middle third and free flaps for the defects over the distal third (Pollak *et al.*, 2000; Chapmen & Olson, 1996). Soleus flap was also advocated for open Gustilo IIIB fractures in the mid shaft of the tibia by Daecke *et al.*, 2007; Kauffman, 2004 and Ger, 1977. Soleus muscle flap supply an expedient solution for some challenging soft tissue problems. The improved knowledge of blood supply to soleus muscle flap allows the design safer, longer and more useful flap. The flaps elevated form the same limb at 0 to 14 days after trauma as soon as the wound will clinically fit for coverage and the flaps will be covered with split thickness skin graft taken from anterior aspect of the thigh in the same sitting in the most of the cases. Although some on advocated split thickness skin graft at about 6^{th} day after the flap surgery and Gustilo suggested a delay of 2 to 5 days (Ger, 1977; Gustilo *et al.*, 1990). Stabilization of the fracture is necessary prior to soft tissue coverage preferable at the day of injury after proper care of the wound. External fixation is a safe and reliable method of achieving osseous stability. The advantages of this technique are versatility, its ease of application with minimal surgical trauma, and its maintenance of wound access (Gustilo, 1993). In the cases of highly contaminated wounds, certainly external fixation is the choice of primary bony stabilization (Cole *et al.*, 1995; Daecke *et al.*, 2007). Unilateral uniplaner frame with double rods gives rigidity to fracture site, less cumbersome and allow better wound access than bilateral or circular frame and interfere less with knee and ankle motion (Behrens & Searls, 1986). Soleus muscle flap is a reliable option for reconstruction of soft tissue defects of middle third of leg. Careful flap dissection with preservation of as many perforators as possible is the key to success. Evaluation of result of early coverage by soleus muscle flap in the wound management of Gustilo type IIIB open fracture of mid shaft of tibia may be helpful to find out the most effective and easiest procedure for part of fracture management in fewer facilities like low socioeconomic condition of Bangladesh. Aim of the objective is to assess the effectiveness of soleus muscle flap for the coverage of wound in open tibia fracture in the mid shaft (Gustilo-type IIIB) at an earlier time.

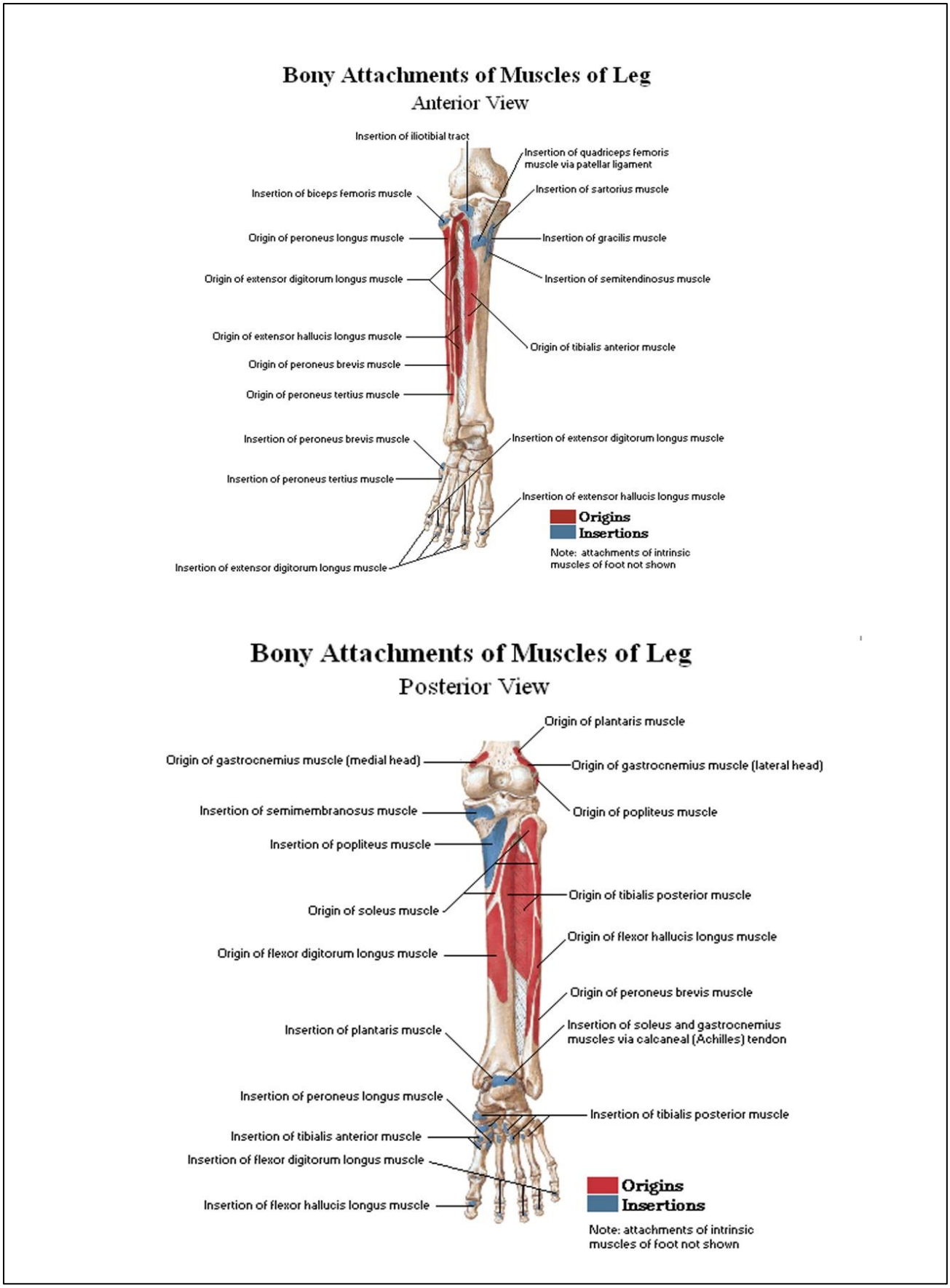

Figure 1: Bony attachment of leg. After Netter (2006)

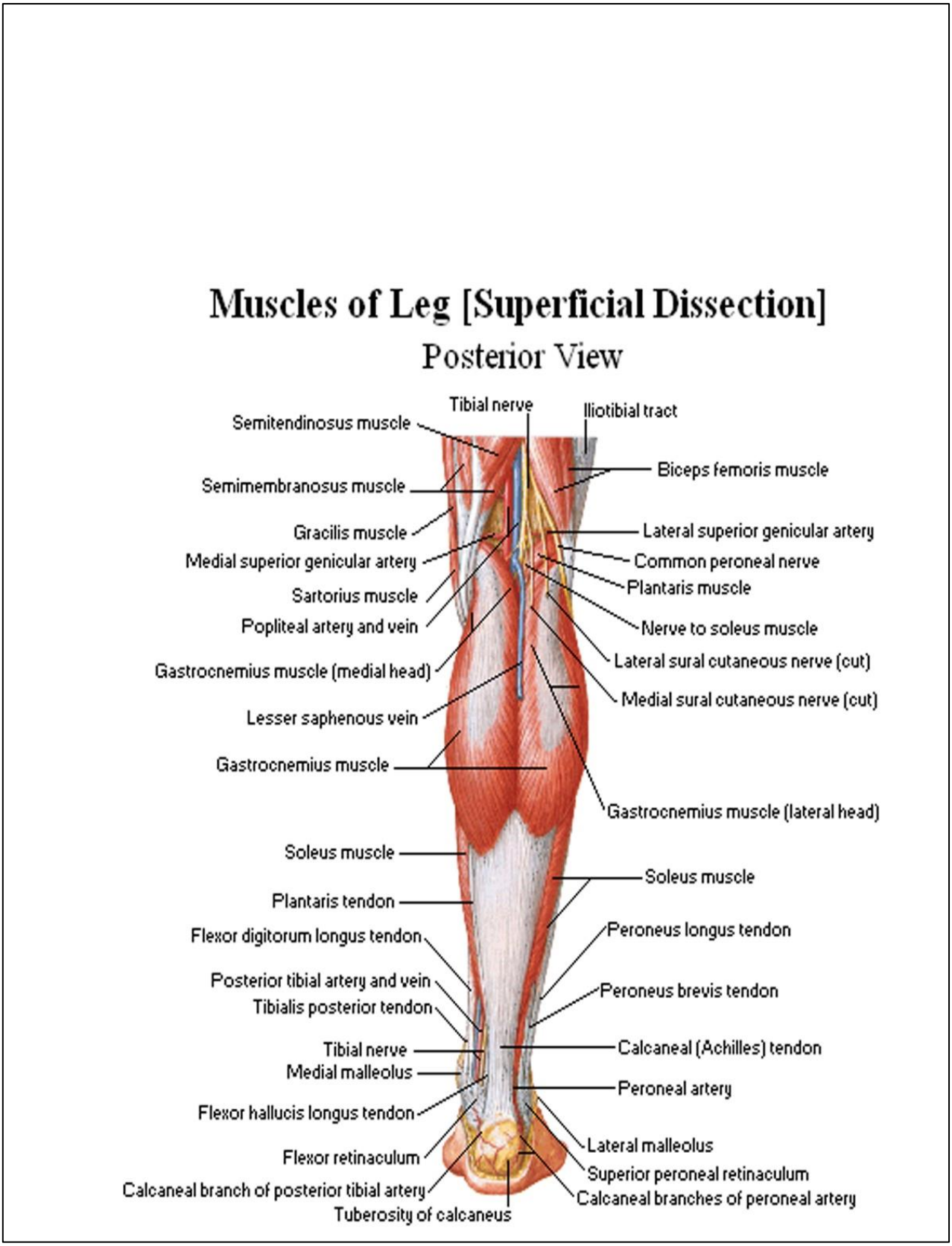

Figure 2: Muscles of Leg – Superficial dissection. After Netter (2006)

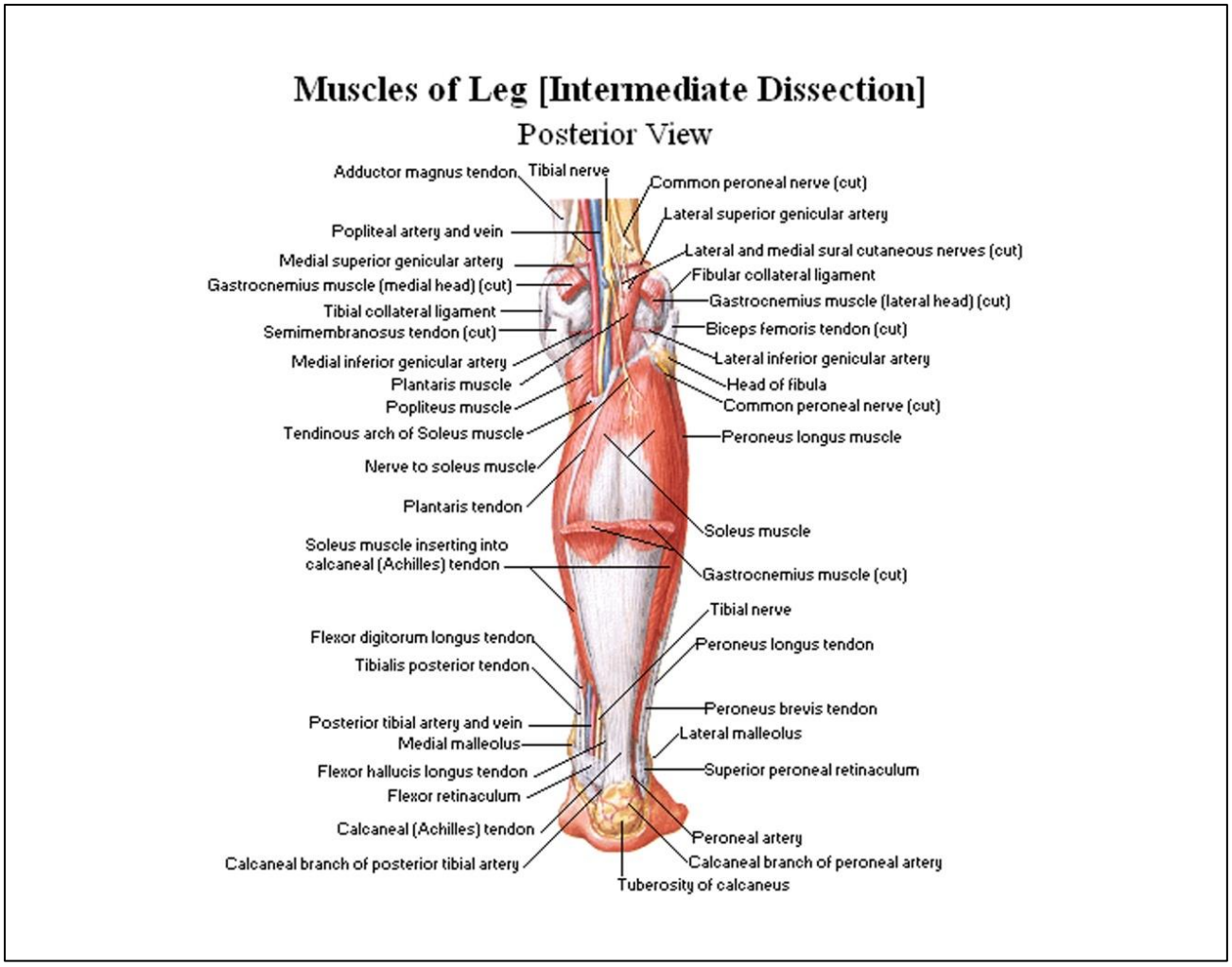

Figure 3: Muscles of Leg – Intermediate dissection-above

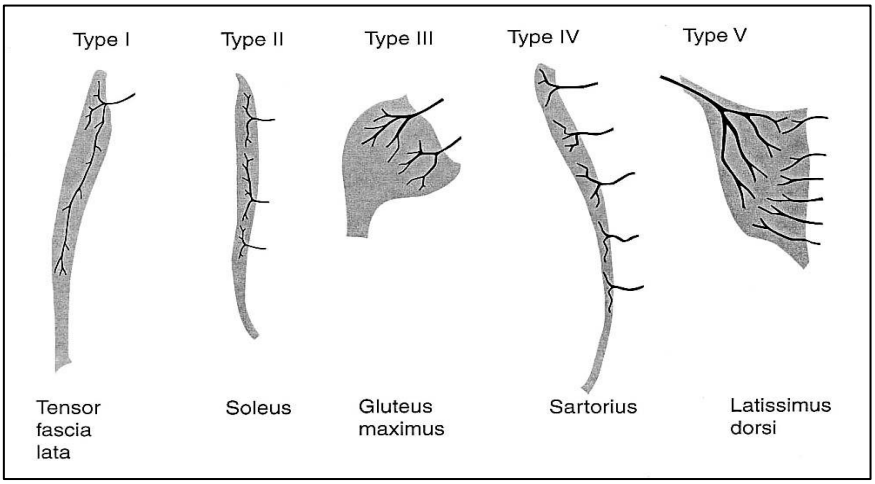

Figure 4: Types of muscle according to patterns of vascular anatomy (After Mathes and Nahai, 1979)

METHODS

This prospective interventional study aimed to evaluate the outcomes of early coverage using the soleus muscle flap in the management of Gustilo type-IIIB fractures of the mid-shaft tibia. The study followed a quasi-experimental design and was conducted over an 18-month period from January 1, 2010, to June 30, 2011. The research took place in the Department of Orthopaedics and Traumatology at Dhaka Medical College Hospital (DMCH) and the National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR) in Dhaka. The study population included all patients admitted to the hospitals with clinical and radiological evidence of open Gustilo type-IIIB fractures of the mid-

shaft tibia. Inclusion criteria comprised patients aged between 16 and 60 years, those with Gustilo type-IIIB fractures of the middle third of the tibia, and open fractures occurring within two weeks of injury. Exclusion criteria included polytrauma patients, individuals with peripheral vascular disease, those with open fractures other than Gustilo type-IIIB, fractures located at the proximal or lower third of the leg, and patients with severe crush injuries over the calf that damaged the gastrocnemius or soleus muscles, or both. Follow-up evaluations were conducted over a 15-week period following flap surgery. Initial assessments were carried out on the 21st postoperative day (POD), and patients were subsequently followed up every two weeks for the first month, then monthly for the next two months. Monitoring included flap site assessment, screening for osteomyelitis or discharge, evaluation of fracture fixation, and identifying and preventing any functional loss. Data collection was conducted using a pre-tested structured questionnaire that recorded variables related to patient history, clinical and laboratory investigations, treatment timing, and perioperative soft tissue and fracture management. Postoperative findings and complications were also documented. A comprehensive data sheet was developed to evaluate final outcomes based on specific criteria, with both pre- and post-operative scoring systems employed to assess functional results and determine the advantages and disadvantages of the procedure. Data were compiled and analyzed using standard biostatistical methods, with SPSS version 15 utilized for statistical analysis. Informed written consent was obtained from patients or their guardians after thoroughly explaining the treatment procedure, anticipated results, possible advantages, disadvantages, and potential complications. Ethical considerations were strictly followed, with confidentiality maintained both verbally and in documentation through the use of secure lockers and password-protected computers. The study protocol received approval from the Ethical Review Committee of Dhaka Medical College.

RESULTS

The present study was carried out between January 2010 and June 2011 at DMCH & NITOR. Total 16 patients of Gustilo IIIB mid shaft tibial fracture were selected but 1 patient was lost during follow up. The purpose of the study was to assess the effectiveness of soleus muscle flap for the coverage of wound in open tibia fracture in the mid shaft (Gustilo- type IIIB) at an earlier time. All the patients, after proper resuscitation and investigation, were treated with whole soleal flap surgery. All the relevant findings obtained from data analysis are presented in tables and figures.

Table 1: Age and sex distribution among the participants

Age in Years	Sex			Mean Age+ SD
	Male	Female	Total	38 ± 12
16-30	5	0	5	
31-45	4	2	6	
46-60	3	1	4	
Total	12	3	15	

Among 15 patients most (12) were male, 3 were female. Mean age was 38 ± 12 years. Majority were in 31-45 years. Male female ratio was 4:1.

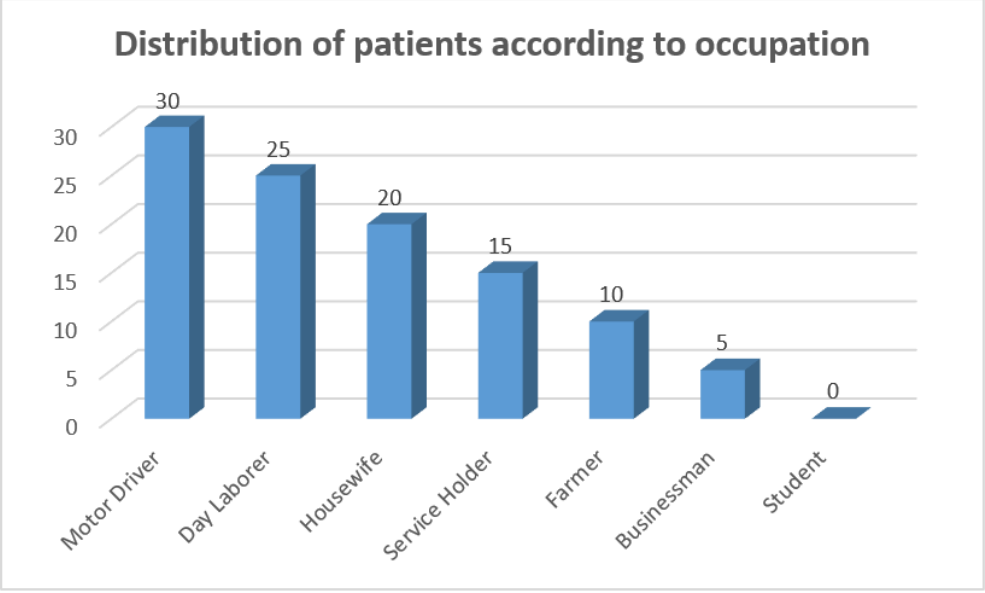

Figure 5: Distribution of patients according to occupation

The selected study subjects were predominantly motor driver (26.66%), followed by day labor, housewife, service holder, farmer, and businessman (each was-13.33%), and student was 6.66%.

Table 2: Causes of injury according to sex & side involvement

Causes	Sex		Side				Total	
			Right		Left			
	Number of male	Number of female	Number	Percentage (%)	Number	Percentage (%)	Number	Percentage (%)
MVA	11	3	7	46.62	7	46.62	14	93.3
Fall from Height	1	0	1	6.66	0	0	1	6.66
Total	12	3	8	53.28	7	46.62	15	100

Among 15 patients 93.3% (14) were victims of motor vehicle accidents (MVA); right and left sides were affected in 8 and 7 patients respectively. Almost all males (11) & all females (3) were victims of MVA.

Table 3: Distribution of fracture configuration

Fracture configuration	Number	Percentage (%)
Comminuted	6	39.96
Oblique	4	26.64
Transverse	3	19.98
Segmental	1	6.66
Bone loss	1	6.66
Total	15	100

Comminuted fracture was in 39.96%, Oblique fracture was in 26.64%, Transverse in 19.98%, Segmental and bone loss each was in 6.66%.

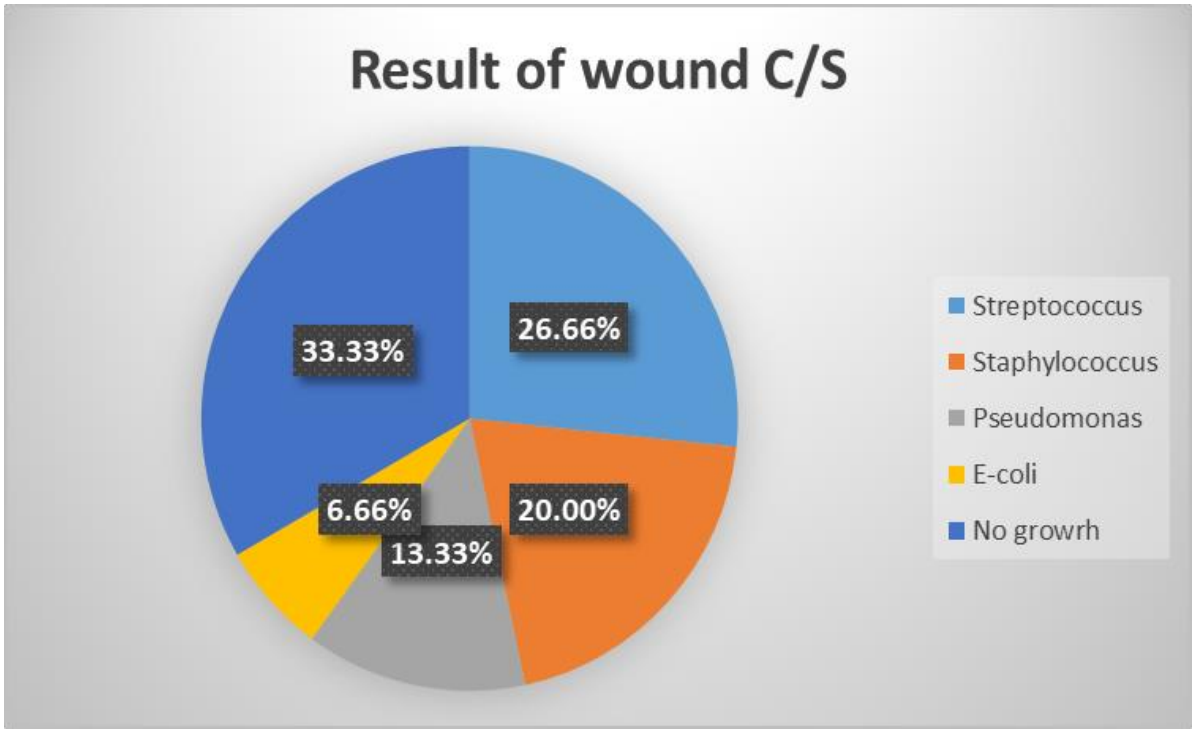

Figure 6: Showing result of wound C/S

Bacteriological culture and sensitivity was performed in every case during final wash out before flap surgery. Out of 15 cases, 5 patients yielded no growth. 4 patients were infected with streptococcal infection. Pseudomonas, staphylococcal and E.Coli infection was 2, 3 and 1 respectively.

Table 4: Distribution of patient by interval of flap surgery and duration of hospital stay (n = 15)

Time interval	Frequency (n = 15)	Percentage (%)	Mean ± SD
Distribution of time interval of flap surgery(days)			
≤7 days	5	33.33	8.9 ± 2.9
> 7 days	10	66.66	
Distribution of patients by time of hospital stay (days)			
<21 days	4	26.64	24 ±4.18
> 21 days	11	73.26	

Five flap surgery was done within 7 days of injury. Most of the flap surgeries were done between 7 to 14 days of injury. Mean time interval between injury and flap surgery was 8.9 ± 2.9 days. In this study mean duration of hospital stay was 24 ± 4.18 days. For most (73.26%) of the cases hospital stay was above 21 days.

Table 5: Distribution of patients on methods of definitive fracture stabilization and Additional procedure for wound coverage (n = 15)

Methods and Procedures	Frequency (n = 15)	Percentage (%)
Distribution of patients on methods of definitive fracture stabilization		
Plaster	3	19.98
IM nail	9	59.94
Ilizarov external fixator	3	19.98
Additional procedure for wound coverage		
Cross leg flap	1	6.66
STSG	1	6.66
Resuturing	1	6.66
No procedure	12	79.92

All the fractures were initially stabilized by external fixator. In case of 9(59.94%) patients IM nail was given after removal of external fixator. Stabilization by long leg full plaster and Ilizarov external fixator each was in 19.98% (3). In most (79.92%) of the cases no additional procedure was needed. One (6.66%) patient required cross leg flap due to >50% flap necrosis. One (6.66%) patient needed STSG due to marginal necrosis and another (6.66%) patient needed resuturing due to flap sagging.

Table 6: Distribution of patients based on range of movement (n = 15)

Range of movement (degree)	Frequency (n = 15)	Percentage (%)
Knee		
0-125	4	26.64
> 125	11	73.26
Ankle Dorsiflexion		
0-10	6	39.96
>10	9	59.94
Planter flexion		
0-30	5	33.3
>30	10	66.66

Regarding range of movement, knee movement was above 125^0 in 73.26 % (11) patients, ankle dorsiflexion above 10^0 in 59.94% (9) patients and planter flexion above 30^0 in 66.66 % (10) patients. Average knee movement was 127.67^0, ankle dorsiflexion and planter flexion were 12.34^0 & 36.34^0 respectively.

Table 7: Outcome of patients based on status of Flap necrosis (n = 15)

Status of necrosis	Frequency (n = 15)	Percentage (%)
No necrosis	12	79.92
Marginal necrosis	1	6.66
Tip necrosis	1	6.66
Necrosis > 50 %	1	6.66

Regarding flap necrosis, 2 (13.32%) patients developed marginal flap or tip necrosis. Out of 2, 1(6.66%) patient required additional procedure. One patient required cross leg flap to cover the defect due to more than 50% flap necrosis.

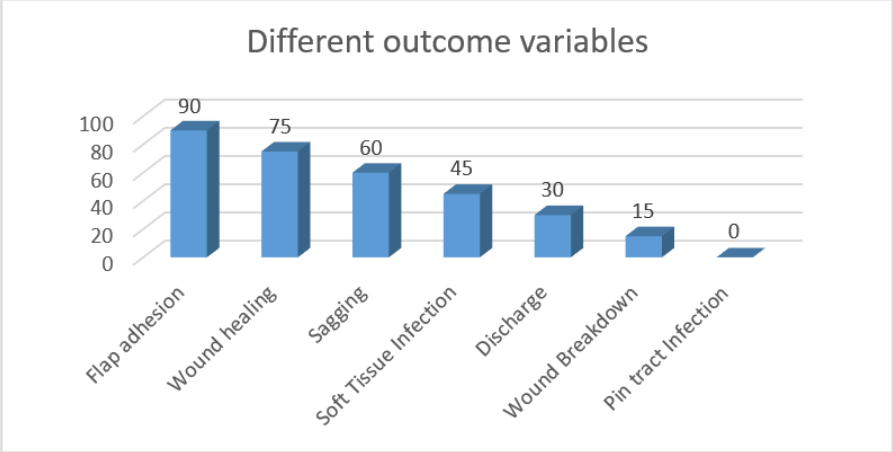

Figure 7: Showing different outcome variables

All most (93.24%) all flaps adhered completely with underlying tissue and wound healed satisfactory. Soft tissue infection developed in 26.64% patients and pin tract infection in 6.66 % cases. Flap sagging occurred in 13.33% & wound break down in 6.66% patient. Subfacial or under flap discharge developed in 46.62 % (7) patients which was treated successfully.

Table 8: Showing final outcome of the patients based on preset criteria (n = 15)

Grade	Frequency (n = 15)	Percentage (%)
Excellent	5	33.33
Good	7	46.66
Fair	2	13.32
Poor	1	6.67

Note: According to preset criteria (appendix-iii), excellent and good outcomes are considered as satisfactory and fair and poor outcomes are considered as unsatisfactory.

Satisfactory = Excellent + Good
= 33.33% + 46.66%
= 79.99%

Unsatisfactory = Fair + Poor
= 13.32% + 6.67%
= 19.99%

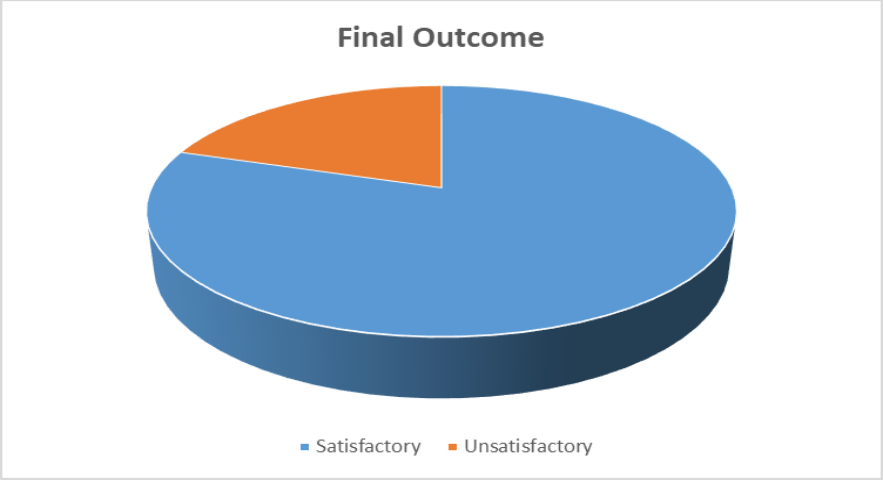

Figure 8: Showing final outcome

Confidence interval of Final Outcome

In this study it is found 79.99% satisfactory result among 15 patients. If this procedure is put in total population then satisfactory result will be found in following confidence interval (at 95% level).

Confidence interval (CI) =

$$P \pm 1.96\sqrt{\frac{p \times q}{n}} \quad (At\ 95\%\ \ level)$$

Here p = 79.99, q=100 – p =20.01, n =15

So, CI= $79.99 \pm 1.96\sqrt{\frac{79.99 \times 20.01}{15}}$

= $79.99 \pm 1.96 \times 10.33$

= 79.99 ± 20.25

= 59.74 % to 100.24%

So, among the population we found almost 60% to 100% satisfactory result by the procedure. It is quite acceptable outcome.

Table 9: Showing outcome variation between <7 days & > 7 days of flap coverage (n = 15)

Flap Coverage	Frequency (n = 15)	Satisfactory Result	Unsatisfactory Results
≤ 7 days	5	5-100%	0%
> 7 days	10	7-70%	3-30%

There is satisfactory outcome in 100% cases where flap coverage done within 7 days.

DISCUSSION

This study was designed to find out an appropriate and accepted technique for re-surfacing of exposed bone at middle third of tibia for management of Gustilo type IIIB open fractures. As a tertiary hospital a lot of cases from far and near of the country either comes directly or were referred to National Institute of Traumatology and Orthopaedic Rehabilitation (NITOR), Dhaka and Dhaka Medical College Hospital. Out of 15 patients, age in this series ranged from 16 to 60 years with a mean age of 38 years. Among them maximum (6) were between age of 31 to 45 years and next (5) were between 16 to 30. This age picture is similar to the study of Pu (2006) & Choudry *et al.,* (2008) mean age was 37 years and 37.5 years respectively. In the study of Caudle and Stern (1987) the age ranged from 17 to 80 years with an average of 36 years. Like all other trauma causes open fracture of the middle third of the tibia fibula are common in the male due to frequency of more traveling. In this study out of 15 cases male were 12 and female were 3 giving the male female ratio of 4: 1. In the previous study Haq *et al.,* (2009) male female ratio was 4:1. In the present series right and left sides affected in 8 and 7 patients respectively. In the study of Pu (2006) the location of soft tissue wound was on right sides in 8 patients and on the left side in 6 patients among 14 patients. Predominantly of them were motor drivers (26.66%), followed by day laborers, housewives, service holders, farmers, and businessmen (each was-13.33%). Almost all patients (93.24%) were victims of Motor Vehicle accidents and the rest 6.66% (1) was due to fall from height. Almost all males (11) & all females (3) were victims of MVAs In the study of Haq *et al.,*(2000) one was injured from firearm injury and the remaining all from Motor Vehicles. In the study of Small & Mollan (1992) and Pu (2006) most of the patients were victims of RTAs. Regarding configuration of fracture comminuted was in 6 patients, indicating a high velocity trauma. Oblique, transverse and segmental configuration was 4, 3 and 1 respectively. One patient presented with segmental bone loss. In the thesis of Uddin (2004) comminuted fracture configuration was 19 and the rest 7 were oblique and bone loss. In the series of Gustilo and Anderson (1976), 70% of open fractures were contaminated with bacteria at the time of injury. In this series Bacteriological culture & sensitivity was performed every cases after arrival at emergency. 6 patients came within 6 hours of injury, out of them 66.66% (4) patient found no growth and 9 patients came after 6 hours of injury, out of them 22.22% (2) patients found no growth in wound swab at emergency. Bacteriological culture and sensitivity was also performed in every case during final washout before flap surgery. Out of 15 cases, 5 patients had no growth. 4 patients were infected with streptococcal infection. Pseudomonas, Staphylococcal and E.Coli infection was in 2, 3 and 1 respectively. In the study of Caudle & Stern (1987) pseudomonas was most common organism followed by Enterococcus and staphylococcus. In the thesis of Uddin (2004) staphylococcal infections was in half of the patients and 6 had no growth. Although timing of flap surgery was not the only parameter, nevertheless, in outcome measurement timing of surgery came out to be the single most important factor regarding better result. Mean time internal between injury and flap surgeries was 8.9 days. Five flap surgeries were done within 7 days of injury. Most of the flap surgeries were done between 7 to 14 days of injury. In the study of Pu (2006) & Shamsuzzaman *et al.,* (2009) all flap reconstructions were done within 10 days & 5 days of initial trauma respectively. Pollak *et al.,* (2000) reconstructed most of the flap within 7 days of injury. Regarding hospital stay average 24 days was required to stay in hospital. In the study of Moda *et al.,* (1994) and Shamsuzzaman *et al.,* (2010) average hospital stay was 3.5 weeks and 3.8 weeks respectively. In the thesis of Uddin (2004) average 36 days hospital stay in flap surgery that done in less than 10 days. All the fractures were initially fixed by external fixator. After removal of external fixator definitive fracture immobilization was done. Majority (59.94%) of the fractures stabilized definitely by IM nail. Ilizarov external fixator was required in 3(19.98%) patients. In case of 19.98% patients after removal of external fixator, long leg full

plaster immobilization was done. In the study of Tornetta III *et al.,* (1993) most of the fractures were internally fixed by IM nail and the rest were by external immobilizer. Pollak *et al.,* (2000) stabilized most of fractures by IM nail (52) followed by external fixator (28) and plate (9). In the current study mean interval between injury and definitive fracture stabilization was 53 days. In the study of McGraw & Lim (1988) interval between injury and IM nailing was 12 wks on average. Regarding flap necrosis, in this study 2 patients developed marginal flap or tip necrosis. Out of 2, 1 patient required additional split thickness skin graft and the remaining 1 healed by granulation tissue. Almost (93.24%) all flaps adhered completely with underlying tissue and wound healed satisfactory. One patient required cross leg flap to cover the defect due to more than 50% flap necrosis and break down of wound. In the study of Gopal *et al.,* (2000), flap failure was 3.5%. In the study of Kauffman *et al.,* (2004) partial necrosis developed in 1 and flap failure was in 1 patient (out of 12 patients) and that of Neale *et al.,* (1982) were 8 and 5 respectively (out of 71 patients). In the study of Pu (2006) one patient developed flap necrosis (out of 14 patients) and was treated by debridement and flap advancement. Chittoria & Mishra (2004) reported 5% partial flap necrosis, 10% infection and 10% partial graft loss in their study. In the current study 7 patients developed collection of discharge in subfacial plane or under the flap. After proper drainage and antibiotics treatment discharge reduced and all the wounds ultimately healed. No patient developed chronic infection or osteomyelitis. Shamsuzzaman *et al.,* (2010) noticed no chronic infection or osteomyelitis in their study. In the study of Haq *et al.,* (2009) and Hutson *et al.,* (2010) one patient developed deep infection which was reduced by drainage and antibiotics. Infection of both soft tissue and bone was the most nagging of all complications. In this study superficial infection developed in 5 cases which were successfully treated by oral antibiotics. Kauffman *et al.,* (2004) reported 4 cases of local infection in their series. In the study of Gopal *et al.,* (2000) 6% patients developed superficial infection, deep infection and pin tract infection were 9.5% and 37% respectively. In the current series 2 patients developed sagging of flap. In one patient sagging was reduced by application of long leg posterior slab for 2 wks. Another patient required resuturing due to re-exposures of bone. In the thesis of Uddin (2004) 2 patients developed post-operative flap sagging. Regarding range of movement, knee movement above 125^0 was in 73.26 % (11) patients, ankle dorsiflexion above 10^0 in 59.94% (9) patients and planter flexion above 30^0 in 66.66 % (10) patients. Average knee movement was 127.67^0, ankle dorsiflexion and planter flexion was 12.34^0 & 36.34^0 respectively. In the study of Tornetta III *et al.,* (1993) in IM nail group, knee and ankle movement was $0\text{-}130^0$ and $0\text{-}35^0$ respectively. In external fixator group knee and ankle movement was $0\text{-}120^0$ and $0\text{-}30^0$ respectively. The desired outcome in the management of type III B open mid tibia fracture is dependent on less number of reconstructive surgical procedure and minimal hospital stay. In the final follow-up according to the preset criteria for evaluation of wound coverage by soleus flap the satisfactory result (excellent and good) was 79.99 % of which 33.33 % excellent and 46.66 % good results. Unsatisfactory (Fair and poor) result was in 19.98% patients of which 13.33 % fair and 6.67 % poor. This finding was nearer to the result of Choudry *et al.,* (2008), Ponten (1981) and Khundkar & Kalam (1996) where success rate were 89%,73% & 85% respectively. Early wound coverage within 7 days demonstrated satisfactory outcome (in 100% cases) than those after 7 days. Ullah (2007) reported that wound coverage within 10 days by muscle flap showing significant satisfactory outcome. Uddin (2004) also showed that sufferings of the patient, cost, laborious surgical procedure reduced if wound cover within 10 days. So early Soleus muscle flap is a valuable option for soft tissue coverage in Gustilo IIIB fracture in middle third of leg.

Limitations of the study

Sample size was small due to limited time period and influence on fracture union could not be observed.

CONCLUSION

Open fracture shaft of tibia are common injuries which are considered as surgical emergency. Adequate wound excision, initial fracture fixation and soft tissue coverage is the key to success. Early wound coverage of Gustilo type-III B fracture of mid shaft of tibia by Soleus muscle flap demonstrated excellent to good outcome and minimal morbidity in majority of the cases. Soft tissue coverage of the exposed bone in Gustilo type III B fractures of middle third of tibia can be satisfactorily covered by soleus flap as it has a rich blood supply with distinct vascular pedicle. Satisfactory outcome can be obtained if the flap is done within one week time after injury.

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