

## ORIGINAL RESEARCH

### A prospective study of analysis of fasciocutaneous flaps at various stages of open tibial fractures

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#### ABSTRACT

**Introduction:** Coverage of open tibial fractures presents unique defects requiring the ingenuity of the surgeon in devising flaps for stable coverage. In our country road traffic accidents are the most common cause of lower limb trauma, followed by fall from height. Though well established norms are in place regarding the time and nature of cover, it requires a team effort with involvement of the orthopaedic surgeon as a rule, and allied specialities like plastic surgeons, general surgeons

**Aims:** To analyze fasciocutaneous flaps reliability in coverage of open tibial fractures

**Materials and methods:** This study was conducted in the Department of Plastic and reconstructive Surgery, Osmania General Hospital, Hyderabad over a period of 24 months from DEC 2019 to DEC 2021. 50 cases age group 10-60yrs of both genders who present with open tibial fractures that are covered with fasciocutaneous flaps, small to medium sized tissue defects of leg. Timing of coverage was classified into Acute- within 72 hours, Subacute- 3 days to 6 weeks, Chronic- Greater than 6 weeks. All the patients included in the study were admitted to the trauma ward under the care of the attending orthopedician and received first aid. They were then resuscitated to minimize bleeding, restore airway and correct shock.

**Results:** The overall incidence of complications in this series of fasciocutaneous flaps was 42%. Distally based fasciocutaneous flaps had a higher complication rate. major complications, usually a failure of the intended coverage, actually more common for proximally based flaps (12.9%) than those distally based (6.3%), although not statically different ( $p=0.436$ ). Infection was the most common complication - 16% of all complications. Total flap loss was seen in only 2 patients which indicated a successful wound coverage in 96%.

**Conclusion:** Flap coverage is best done within 72 hours of injury. Overall early surgery significantly reduces patient's morbidity, decreased hospital stay and early return to work.

**Keywords:** Fasciocutaneous flaps, Tibial fractures, Complications.

#### INTRODUCTION

Coverage of open tibial fractures presents unique defects requiring the ingenuity of the surgeon in devising flaps for stable coverage. In our country road traffic accidents are the most common cause of lower limb trauma, followed by fall from height. Though well established norms are in place regarding the time and nature of cover, it requires a team effort with involvement of the orthopaedic surgeon as a rule, and allied specialities like vascular

surgeons, general surgeons. Despite stable fixation being obtained earlier, the timing of soft tissue cover varies owing to several factors like availability of reconstruction team, doubtful vascularity, skill of the attending surgeon, concomitant injuries to the lower limb, comorbid factors, prolonged anaesthesia time etc.

Less-severe open tibial fractures (Gustilo grades I to IIIA) can be successfully treated with early wound debridement, internal fixation, and wound closure, whereas Gustilo grade IIIB and IIIC fractures require complex soft-tissue coverage, and are associated with higher rates of infection, non-union, eventual amputation, prolonged hospitalisation, time lost from work, and drain on financial resources.<sup>1</sup>

Latest treatment guidelines advocate early soft-tissue cover and fracture fixation within 72 hours; some even recommend a radical single-stage 'fix and flap' approach. Though Free tissue transfer has revolutionised coverage of leg defects it may not be feasible to have the personnel with the necessary skill at that time. Fasciocutaneous flaps and Muscle flaps still have well established roles to play in extremity reconstruction. Plastic surgery becomes not only important in covering a raw area, but also in providing a functional limb with an acceptable aesthetic result. Though we live in an era of zero delay work, microvascular transfer and a single stage work up, often owing to circumstances beyond our control, it may still be necessary to revisit the older methods which are reliable, comparable and easily reproduced.<sup>2,3</sup>

There is need to challenge the concept, that distally based flaps are inferior to proximally based flaps just as the dogma that skin flap survival depends on rigid length to width ratios has been refuted. Adjusting all other factors, the true critical factor of flap viability is the nature of their intrinsic blood supply rather than any arbitrary orientation or configuration in either case.

The preconceived notion that superiorly based flaps are superior to inferiorly based flaps has been disproved by Hallock who in his study found that, the inclusion of a dominant source vessel, its perforators to a given skin territory, their interconnected choke vessels, and the resulting span of the adjacent captured link are the actual major determinants predicting flap survival and not the orientation of the flap pedicle perse. There are several unique situations in which overall risk of flap failure may be minimised by the selection of a proximally based flap. Because arterials gradients, especially in the dysvascular patient, diminish toward the periphery, reverse perfusion may be inadequate to capture a proximal territory, whereas the converse may not be true. Venous valves in the lower extremity tend to be thicker, less pliable, and more competent because of their routine exposure to greater hydrostatic pressures, so that distally based flaps tend to be riskier if venous outflow must depend on retrograde regurgitation. Thus if only a proximally based flap is chosen, the great potential of distally based flaps for coverage of the most acral portion of the extremity, where other local flaps don't exist will be overlooked. In addition, because the resulting donor site could be located proximally, usually overlying muscles, the donor site morbidity is actually less than that of a proximally based flap. Thus it is imperative to enhance our quality of work in those areas to produce a good result with a few complications as possible. It is with this idea that the study was done.

## **MATERIALS AND METHODS**

This study was conducted in the Department of Plastic and reconstructive Surgery, Osmania General Hospital, Hyderabad over a period of 24 months from DEC 2019 to DEC 2021.

## **INCLUSION CRITERIA**

All patients age group 10-60yrs of both genders who present with open tibial fractures that are covered with fasciocutaneous flaps, small to medium sized tissue defects of leg.

**EXCLUSION CRITERIA**

Patients with degloving injuries, arterial injury, head injury, abdominal injury, thoracic injury, bony injury elsewhere, brachial plexus injuries, Patients were whom skin grafts are planned, with diabetes, hypertension, smokers, age > 60 yrs

A minimum of 50 cases will be studied.

Timing of coverage was classified into

**Acute-** within 72 hours

**Subacute-** 3 days to 6 weeks

**Chronic-** Greater than 6 weeks

All the patients included in the study were admitted to the trauma ward under the care of the attending orthopedician and received first aid. They were then resuscitated to minimize bleeding, restore airway and correct shock.<sup>4</sup>

Detailed history was taken on the mechanism of injury; the time since injury and history of neurological deficits. Then all the patients were subjected to a full general and local clinical examination to rule out other coexisting injuries and to assess the site and size of the defect, the presence or absence of exposed bone, tendons or neurovascular structures, the degree of wound contamination and the condition of surrounding skin. A complete vascular and neurological examination with comparison to the other healthy limb was performed.

Laboratory investigations necessary for surgical fitness were done. X-rays and hand held Doppler studies were done to identify and classify the fracture and assess vascular status with Doppler study or CTAngio. All patients were taken up for wound toilet and debridement on the day of admission. Skeletal stability was achieved if necessary with external fixators, illizarov ring fixators, plates or K-wires as deemed appropriate by the orthopedic surgeon. To control the infection the wound pus culture and sensitivity done and the systemic antibiotics used accordingly. Wounds were dressed daily with a saline dressing. Once the wounds were free of infection the soft tissue cover was planned. The appropriate reconstructive technique was selected for every patient considering the site, size and type of the defect, the condition of local tissues, previous surgical procedures in the injured limb, future planned surgical procedures and the patient's general condition. In Acute situations where immediate cover was done, the wound was debrided by the Plastic surgeon prior to skeletal fixation. In other cases wounds were debrided initially by the orthopaedic team and again during the cover by the plastic surgeons. Defects were classified according to their site as per the usual norms of upper third, mid third and lower third.

All the patients received postoperative care including proper antibiotic therapy, analgesics in the post-operative period, elevation of the limb to prevent oedema and monitoring of the flap-colour, temperature and capillary refill. First look dressing of the skin graft was done on the 5<sup>th</sup> postoperative day. Assisted ambulation was allowed for the patients whenever possible at the end of the 5<sup>th</sup> postoperative day. Dependable weight bearing was allowed at the end of the 7<sup>th</sup> postoperative day depending on the presence of bone fractures and the method of bone fixation. Sutures were removed on the 10<sup>th</sup> postoperative day and the patients were transferred back to the orthopedic surgeon for further treatment. Patients were evaluated on their 1<sup>st</sup>, 5<sup>th</sup>, 10<sup>th</sup>, 13<sup>th</sup>, 30<sup>th</sup> and 60<sup>th</sup> postoperative day. Evaluation parameters included viability and stability of the flap, take of the skin graft for secondary defect, presence of pain, ulceration, functional deficit, hospital stay and patient satisfaction with the reconstruction. On the 30<sup>th</sup> day patients were asked to subjectively grade the reconstruction in terms of functionality, return to work and aesthetic appeal. Follow up periods varied from 6 months to two years depending on the patient's compliance.<sup>5</sup>

**RESULTS**

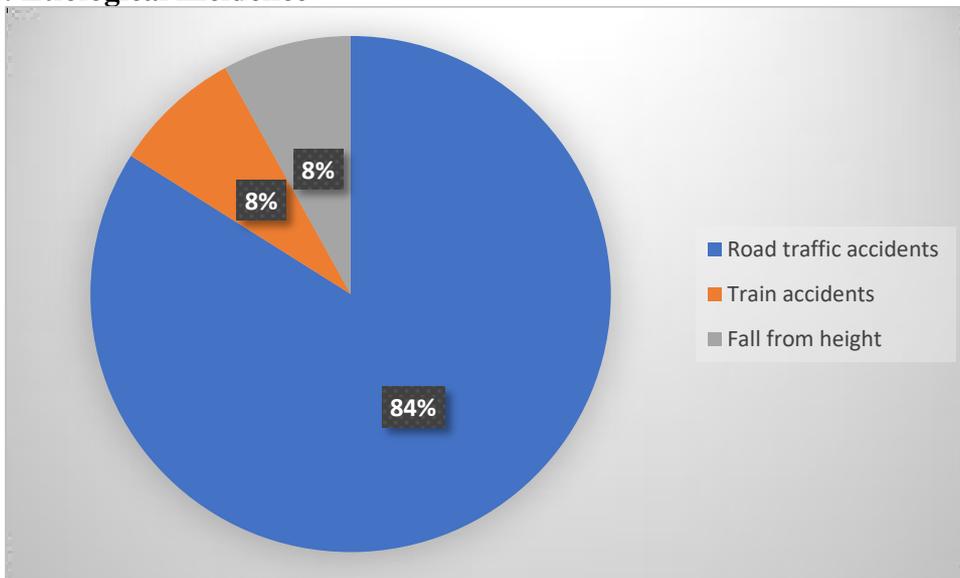
The age of patients ranged from 10 to 60 years in this study. Common age group affected is between 21 to 30 years (n=15).

Male to female ratio is 11.5: 1 (M = 46, F = 4).

**Table-1: Age distribution in present study**

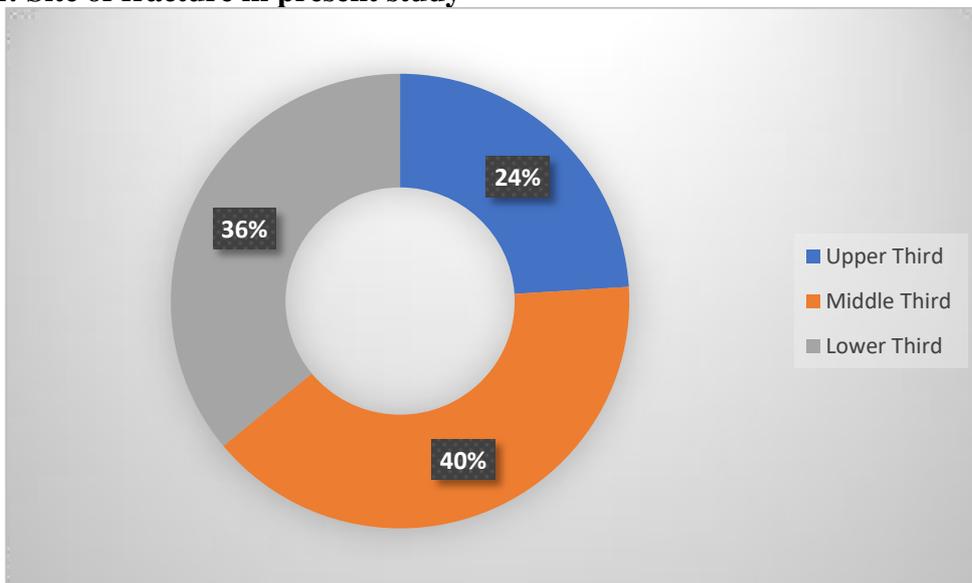
Age in range	Male	Female	Total (%)
10-20	2	1	3(6%)
21-30	13	2	15(30%)
31-40	11	1	12(24%)
41-50	10	-	10(20%)
<b>51-60</b>	10	-	10(20%)
<b>TOTAL</b>	46	4	

**Figure-1: Etiological Incidence**



The etiological indications for fasciocutaneous flap cover in this study showed Road traffic incidents to be the most common cause at 84%

**Figure-2: Site of fracture in present study**



The fasciocutaneous flaps in this study were most commonly used for middle third leg defects 40%, followed by lower third 36% and upper third 24%.

**Table-2: Phase of coverage in present study**

Phase of coverage	Number of cases	Percentage
Acute (within 72 hours)	2	8
Subacute (72 hours - 6 weeks)	44	88
Chronic (beyond 6 weeks)	4	8

In this series maximum number of fasciocutaneous flaps were done in the subacute phase - 88% and the least in the acute phase 4%.

**Table-3: Type of fasciocutaneous flap cover**

Type of flap	Number of cases	Percentage
Superiorly Based Fasciocutaneous Transposition Flap (SFCTF)	9	18
Inferiorly Based Fasciocutaneous Transposition Flap (IFCTF)	20	40
Reverse Sural Neurofasciocutaneous Flap (RSA)	12	24
Cross Leg Flap (CLF)	1	2
Propellar Flap (PF)	3	6
Venous Flap (VF)	3	6
Keystone Flap (KSF)	2	4

Inferiorly based fasciocutaneous flaps were the most commonly used in this study accounting for 40% of all flaps.

The orthopaedicians preferred mode of skeletal stabilisation was external fixation in 88% and internal fixation in 6 cases ie 12%

**Table-4: Complications of various types of flaps**

Complication	Number of cases	Percentage
Dehiscence	2	4
Partial Necrosis	3	6
Complete Necrosis	2	4
Superficial Necrosis	2	4
Infection	8	16
Venous Congestion	4	8
Nil	29	58

Infection was the most common complication in this series, it was managed by conservative measures - Appropriate antibiotics / Irrigation,

Venous congestion was managed by -suture removal at the site of maximum tension, limb elevation, intravenous fluids, massaging of flap and debridement of necrosed tissue.

Partial flap loss was managed in 2 ways

1. Where bone was not exposed, wound was allowed to granulate after removing the necrosed part and covered with split skin graft.
2. Where bone was exposed, the patient was taken to the operation theatre and the flaps were adjusted after shifting the pedicle further proximally or distally as needed.

Complete necrosis and superficial necrosis observed in 2 cases of each.

**Table-5: Correlation between complication and flaps**

Complications	SFCTF	IFCTF	RSA	CLF	PF	VF	KSF
Dehiscence	0	0	1	1	0	0	0
Partial Necrosis	0	1	0	0	1	1	0

<b>Complete Necrosis</b>	<b>0</b>	1	.1	.0	.0	0	.0
<b>Superficial Necrosis</b>	<b>0</b>	2	.0	.0	.0	0	.0
<b>Infection</b>	<b>1</b>	3	3	1	0	0	0
<b>Venous Congestion</b>	<b>0</b>	1	3	0	0	0	0
<b>Nil</b>	<b>8</b>	12	4	0	2	2	2
<b>Total</b>	<b>1</b>	8	8	1	1	1	

In Superiorly Based Fasciocutaneous Transposition Flap (SFCTF) Complication almost nil in this study, minor infection observed in 1 case .

In Inferiorly Based Fasciocutaneous Transposition Flap Partial necrosis in 5% of cases, infection 15%,venous congestion in 5%, superficial necrosis in 10%,complete necrosis 5% and nil complications in 60% Reverse Sural Neurofasciocutaneous Flap (RSA) Dehiscence in 8.3% cases, complete necrosis in 8.3%, venous congestion in 25%,infection in 25% and nil complications in 33.3%

In Cross Leg Flap Complete dehiscence of one crossleg flap seen in this study.(100%).

In Propellar Flap Partial necrosis in 33%, nil in 66%

In Venous Flap Partial necrosis in 33%, nil in 66%in Keystone Flap Nil complication in 100% cases

**Table-6: Complications during various phases of cover**

<b>Complications</b>	<b>Early</b>	<b>Subacute</b>		<b>Chronic</b>
Dehiscence	1			1
Partial Necrosis		3		
Complete Necrosis		1		1
Superficial Necrosis		2		
Infection	1	6		1
Venous Congestion		3		1
Nil				
	<b>Total</b>	2(9.5%)	15(72%)	4(19%)

Complications are high in the subacute phase rather than the chronic cases surprisingly mirroring the early phase in contradistinction to other studies, perhaps owing to adequate preparation with repeat debridements, sequestrectomies, antibiotic cover and wound homeostasis in the interim period with adequate skeletal stabilisation.

**Figure-3: Type of fasciocutaneous flap cover**



**Superiorly based fasciocutaneous Transposition flap**



**Inferiorly based fasciocutaneous Transposition flap**



**Reverse sural artery Neurofasciocutaneous flap**



**Propellar Flap**



**Venous Flaps**



**Keystone Flaps**

**DISCUSSION**

In this study the age of the patients varied from 10 years to 60 years with Common age group affected is between 21 to 30 years (n=15),30%. In the series of Gururaj and Suri MP et al<sup>6</sup>,common age group affected is between 25-35 years. In this study,92%(n=46) of those operated were males while other studies have quoted 64% (Gururaj and Akthar et al). Male to

female ratio is 11.5:1. Males may be more commonly affected owing to their increased mobility, usage of two wheelers and ingestion of alcohol.

Road Traffic Accident - 42 patients, Fall from Height - 4 patients and Train Traffic Accident - 4 patient . The etiological indications in this study showed Road traffic accidents to be the most common cause at 84 %.In a study by Franken, Hupkens&Spauwen et al<sup>7</sup> also showed Road traffic accidents continue to be the major cause of open tibial fractures in a developing country like ours just as in the developed nations. A better adherence to road rules, stricter licensing laws and a curb on drunken driving could decrease the incidence of open tibial fractures.

The fasciocutaneous flaps in this study were most commonly used for middle third leg defects 40%, followed by lower third 36% and upper third 24%. With increasing use of muscle flaps with skin grafting for upper third defects the indication for fasciocutaneous flaps for upper third defects is less- 24%. .In a study by Franken, Hupkens&Spauwen et al<sup>7</sup> in 35 patients, seven patients(20%) had proximal third defect, seven patients had(20%) at middle third defect and 21 patients (60%) at distal third.

The orthopaedicians preferred mode of skeletal stabilisation was external fixation in 88%, despite conclusive studies by Trabulsky et al<sup>8</sup> fixators proving non-reamed locked nails were more effective than external fixators. Again this may reflect availability rather than personal preference.

Most number of cases were operated on for cover at the subacute phase 88% and in the chronic phase 8% with the least number in the acute phase 4%. This is in total contrast to literature elsewhere where early cover is recommended. (Godina et al, Byrd et al).<sup>2</sup>

The reasons for the decreased immediate cover wereCo existing head injury taking priority for management, Lack of immediate referral by orthopaedicians, Doubtful vascularity of the limb, Co existing wounds on the leg requiring skin grafting, Co morbid illnesses with patients on Aspirin for ischaemic heart disease and Delayed skeletal stabilisation where internal fixation was used.

The results from other studies showed that immediate wound reconstruction is preferred to delayed wound reconstruction in that it shortens the period of hospital stay significantly, few dressing changes, fewer operations, decreased infection rate and secondary necrosis of exposed tissues. Thus, early consultation for soft tissue reconstruction is advised and all attempts should be done to perform immediate reconstruction. These results are in agreement with previous studies.

We emphasize the importance of co-operation at the time of primary surgery between orthopaedic and plastic surgeon to preserve access to potential flaps. The technique of bony fixation of the tibia may prevent the use of this flap, especially in the presence of external fixation pins which may injure perforating vessels or tether the flap, restricting its range of transposition.

Inferiorly based fasciocutaneous flaps were the most commonly used in this study accounting for 40% of all flaps,followed by reverse fasciocutaneous flaps(24%). Inferiorly based Fasciocutaneous flap from lateral side is the most common procedure performed for small to medium sized defect as the perforator is constant and reliable in the lower lateral aspect of the leg. Neurofasciocutaneous flaps are excellent choice for medium to large size defect. Propeller flap done in 3 cases (6%), all flaps survived well. In one case, distal partial necrosis of 1cm observed, for which debridement and flap readjusted to cover the exposed bone.

Venous flaps done in 3 cases(6%) for upper third defect,but in one case,we observed distal necrosis flap upto 3cm,for which necrosed flap was debrided and flap readjusted by giving back cuts. Keystone flap done in 2 cases(4%) ,one is implant exposure over proximal tibia,another one is lower third leg defect. Flaps survived well without any complications.

The use of microsurgical techniques for the difficult problems revolutionized the field with literally limitless tissue available for transfer and defects deemed to be unsalvageable were suddenly salvageable, but with the advent of newer techniques like perforator flaps and neurocutaneous flaps there is a resurgence of interest in non microsurgical reconstructive options. This is of special significance in a resource challenged centre like ours. In this study we have attempted to explore the above mentioned reconstructive strategies for open tibial fractures. However the indications and the criterion of selection of a particular technique for a particular defect are not well established and is rather a matter of personal judgement.

While raising the local fasciocutaneous flap we always tried to include the perforator at the base of the flap, which was identified pre-operatively with hand held Doppler.

Infection (n=8) 16% was the most common complication in this series, it was managed by conservative measures – Anti-oedema measures, appropriate antibiotics / Irrigation. Venous congestion (n=4) 8%, (3 Reverse sural artery neurofasciocutaneous flaps, 1 Inferiorly based fasciocutaneous flap was managed by -suture removal at the site of maximum tension, limb elevation, intravenous fluids, massaging of flap and debridement of necrosed tissue.

Partial flap loss in three patients, 6% ( 1 Inferiorly based fasciocutaneous flap ,1 propellar flap and 1 venous flap ) was managed in 2 ways 1. Where bone was not exposed, wound was allowed to granulate after removing the necrosed part and later covered with split skin graft. 2. Where bone was exposed, the patient was taken to the operation theatre and the flaps were adjusted after shifting the pedicle further distally as needed. Total flap loss in 2 cases, 4% ( 2 Reverse sural artery neurofasciocutaneous flaps) were covered with a skin graft after allowing it to granulate after making drill holes in the exposed bone and the other reconstructed with alternate flap cover. Superficial necrosis seen in 2 cases, 4% (2 Inferiorly based fasciocutaneous flap) was managed by superficial debridement and skin grafting. -Dehiscence observed in 2 cases, 4% (1 Reverse sural artery neurofasciocutaneous flap and 1 cross leg flap). Resuturing was done for reverse sural artery fasciocutaneous flap with minimal dehiscence, for cross leg flap, flap returned back as not maintaining position and infection of flap.

The overall incidence of complications in this series of fasciocutaneous flaps was 42% which is higher compared to Hallock's<sup>9</sup> series which had a complication rate of 22.5%. Distally based fasciocutaneous flaps had a higher complication rate than others in contrast to Hallock's series<sup>9</sup> where major complications, usually a failure of the intended coverage, actually more common for proximally based flaps (12.9%) than those distally based (6.3%), although not statistically different (p=0.436). Infection was the most common complication - 16% of all complications. Total flap loss was seen in only 2 patients which indicated a successful wound coverage in 96%.

This was similar to Hallock's series<sup>9</sup> in which local fasciocutaneous flaps obtained ultimate wound closure in 97%. Complications were greatest in the subacute phase (72%) although most of cases operated in subacute phase 88% (n=44). the chronic cases (19%) surprisingly mirrored the early phase (9.5%), perhaps owing to adequate preparation with repeat debridements, sequestrectomy, antibiotic cover and wound homeostasis in the interim period with adequate skeletal stabilisation.

Complication rate was least in those cases given early cover, highest in the sub acute phase and in chronic cases the complication rate was comparable to acute phase. The complication rates for the acute and sub acute phases were correlating with Byrd series where he had complication rates of 18% and 50% respectively.<sup>10</sup> This present study has similar results with study conducted by Weiliang Chua et al).<sup>11</sup> they concluded that, severe open tibial fractures, early soft tissue coverage (within 72hrs) was associated with more favourable outcomes in terms of length of hospitalization and infection.

But present study results are in contrast to study by Franken, J.M et al<sup>7</sup>, treatment with a fasciocutaneous flap associated with significantly more postoperative complications than musculocutaneous flap. There was no significant difference after a early or late flap coverage. But Cierny et al<sup>12</sup>, Kamath JB et al<sup>13</sup> and Naeem Jagani et al<sup>14</sup> studies had similar conclusions. They concluded that open fracture of tibia which needs flap coverage should be treated with high priority of radical early debridement, rigid fixation and early flap coverage.

**Table-7: In comparison to Godina M series the following observations were seen**

	Present Study		Godina M series <sup>15</sup>	
	Infection	Flap loss	Infection	Flap loss
<b>Early phase</b>	2%	nil	1.5%	0.75%
<b>Subacute phase</b>	12%	2%	17.5%	12%
<b>Chronic phase</b>	2%	2%	6%	9.5%

Based on the above observations, This once again emphasises the need for early cover. There was a significantly lower infection rates in the subacute phase and chronic phase with fasciocutaneous flaps than microvascular free flaps. This may be due to the quiescence in the tissues/adequate antibiotic cover, established stability of the skeleton, the necessity to dissect for a donor vessel in the free flaps. There was no difference in the infection rates in early phase with fasciocutaneous flaps and microvascular free flaps. Flap loss rates were also significantly lower in all phases with fasciocutaneous flaps in comparison to free flaps. Though free tissue transfer has revolutionised coverage of lower 1/3<sup>rd</sup> eg defects it may not be feasible to have the personnel with the necessary skill and facilities at that time. Fasciocutaneous flaps and reverse neurofasciocutaneous flaps still have well established roles to play in lower extremity reconstruction. Limb reconstructive is a long and complicated process in which unlike other surgical emergencies protocols are still evolving and evidenced based guidelines are not available. In present scenario the healthcare delivery is influenced by cost of care. And hence the surgeon needs to choose the procedure which in his hands would give best result, keeping in mind, the best interest of patient.

## CONCLUSION

Fasciocutaneous flaps are reliable, safe, fast to learn flaps for leg defects. Males continue to be at high risk for compound tibial fractures particularly from Road traffic accidents. Stricter road safety protocols, safer roads, strict licensing could perhaps decrease the incidence of open tibial fractures. Most cases in this study were operated on in the subacute phase which had the highest complication rates also indicating the need for early referral by the orthopaedician, a combined team approach, and involvement of the plastic surgeon in the planning of the case from the trauma ward itself. The fact that there was no difference between free flaps and fasciocutaneous flaps in terms of flap loss indicate that the fasciocutaneous flaps can be safely done in the emergency sitting, where facilities for microsurgical transfer are not available, with the added advantage of decreased operating time. No necessity for two teams and no alterations in the haematological parameters Distally based fasciocutaneous flaps had a higher complication rate. Flap coverage is best done within 72 hours of injury. Overall early surgery significantly reduces patient's morbidity, decreased hospital stay and early return to work.

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