

# A single stage management procedure of gustilo type-III open tibial fractures by Ilizarov with secondary clouser and flap transplantation: an article

## Abstract

**Introduction:** The management of Gustilo-Anderson type-III open tibial fracture is complex due to neurovascular damage and soft tissue loss. Combined orthopedics, plastic and vascular surgery provides better result for reconstructing the injuries of limb. The prevalence of tibial shaft fractures is estimated about 67%.<sup>1,2</sup> Tibial shaft fractures are approximately 15% of all adult fracture and open tibial fractures are about 23.5%.<sup>1</sup> Rigid fixation and good soft tissue coverage are essential for management of the fracture. Ilizarov external fixator, provide multi-disciplinary management of type III open tibial fractures with sever contamination and comminution.

**Purpose of the study:** To evaluate the clinical efficacy of Ilizarov external fixator with or without fascio-cutaneous flap transplantation in the management of Gustilo-Anderson type-III open tibial fracture.

**Methodology:** In the period of 2020 -2021, we manage 5 cases of Gustilo- type-III open tibial fracture by Ilizarov. 2 patients were type-III A and 3 type-III B with severely contaminated and comminution. No neurovascular damage. All are male, age 30 -65 years and caused by RTA. There was 1 diabetic and 1 hypertensive patient. Surgical toileting, debridement and posterior slab apply as immediate management. All patients managed by Ilizarov on 5<sup>th</sup> and 7<sup>th</sup> day with secondary closure of type-III A and vascularized fascio-cutaneous flap with skin grafting in type-III B cases by orthopedic and flap surgeon.

**Summary:** Full weight bearing was allowed on 3<sup>rd</sup> POD. Soft tissue was healed within 3-6 weeks. In 1 case found skin infection, treated by antibiotic and dressing, also 1 case occurred flap edge necrosis, managed by debridement and 2<sup>nd</sup> time skin graft. Bone union time was 5-6 months, RUST scores 10. According to ASAMI score all were excellent results.

**Conclusion:** RTA is the main cause of type III open tibial fractures. Combined multi-disciplinary managements by Ilizarov provide excellent outcomes, early mobilization and infection control. It is a single stage definite management, which reduce treatment cost, patient's mortality and morbidity.

## Message of the article

Previously, primary amputation was done in severely injured leg. Secondary amputation of the limb predominated among the patients of Gustilo-Anderson type-III B open tibial fracture was-25% and type-III C-75% due to serious complication like-infection, soft tissue loss, neuro-vascular damage etc.<sup>1</sup> In day by day clinical advances of medical science and availability of facilities, it is possible to overcome the limitations. Now various studies suggested that salvage is a cost benefited strategy that provides a better quality of life than amputation. Combined orthopedics, plastic and vascular surgery (Ilizarov with/without flap transplantation single stage procedure) provides more options for reconstructing the injured limb of Gustilo-Anderson type-III open tibial fracture.

**Keywords:** gustilo-anderson type-III open tibial fracture, Ilizarov, secondary closure, flap transplantation

**Abbreviations:** ASAMI, association for the study and application of the method of Ilizarov; GA, gustilo-anderson; POD, post-operative day; RTA (MVA), road traffic accident (motor vehicle accident); RUST, radiographic union score for tibia; GCS, glasgow coma scale; ASA, american Society of anesthesiology; ISS, injury severity score; NISS, new injury severity score

## Introduction

The management of Gustilo-Anderson type-III open tibial fracture is complex due to neurovascular damage and soft tissue loss. Combined orthopedics, plastic and vascular surgery provides more options for reconstructing injuries to the limb. The early bone fixation and wound coverage enhance bone union, early mobilization,

reduce infection rate and hospital cost. The cause of injury is high energy trauma, mainly RTA, which is 53.5%. Young males are mostly affected. Trauma is the 6<sup>th</sup> leading cause of mortality and 5<sup>th</sup> leading cause of morbidity worldwide. In developing countries, mortality and morbidity due to RTA is the 3<sup>rd</sup> most health problem by 2020.<sup>3</sup> GA type-III open tibial fracture associated with others long bone fracture is about 2.9%. Fractures patterns are mostly comminuted (25.7%) and mid shaft of tibia are mostly affected (14.3%).<sup>4</sup> Infection is the major complication and the rate is 28.6% in IIIA, 44.4% in IIIB and 100% in IIIC open tibial fracture. Secondary amputation needed 25% in type IIIB and 75% in type IIIC tibial fracture. Wound debridement <48 hours, the infection rate is 20% and >48 hours it is 60%. The treatment of the fracture is fixation by IMN, plate and external fixator with or without fascio-cutaneous flap transplantation. Rigid

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fixation and good soft tissue coverage are essential for management of the fracture. In IIIA, primary closure done-35.7% and secondary closure-21.4%, IIIB, secondary closure done-44.4%, skin graft-27.8% and flap-27.8% and IIIC, flap done-3%.<sup>4</sup> Reamed nailing is the choice of open tibial fracture treatment with less contamination and fragment comminution. Application of external fixation has great success rate. Ilizarov is a special type of external fixator, provide multi plenary plan of action to manage type III open tibial fractures.

## Methodology

It is a retrospective descriptive study carried out in a specialized private hospital, Sylhet, Bangladesh, where all costs paid by patients. A detailed history and informed written consent was taken. Data was collected from hospital records with written permission of authority. In this study patients included only Gustilo-Anderson type-III open tibial fracture adult patients age >20 years, others patients like poly-trauma and age <20 were excluded. In the period of 2 years (2020-2021), we managed 5 cases of Gustilo-Anderson type-III open tibial fracture by Ilizarov fixator with/without flap transplantation. All patients were examined thoroughly and history taken according to ISS, NISS, GCS and ASA. Each of them stabilized first and given necessary emergency treatment as per standard protocol. Anti-tetanus prophylaxis and venous thrombo-prophylaxis guidelines were followed of all patients. Final outcomes all of 5 patients were excellent. Data analysis was done by spss 25.0 statistical software, MS word and Excel version 2010.

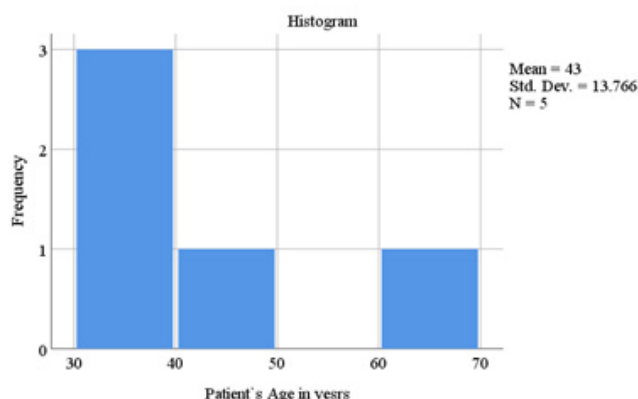
## Data analysis results

Demographic data include age, sex, pre injury comorbidities and mobility.

**Age:** The maximum age of the patients was 65 years and the minimum was 30 years. The mean age ( $\pm$ SD) was 43 ( $\pm$ 13.766) years (Table 1).

**Table 1** Showing the age distribution of patients. (n=5)

| Age            |        |
|----------------|--------|
| Mean           | 43     |
| Std. Deviation | 13.766 |
| Minimum        | 30     |
| Maximum        | 65     |

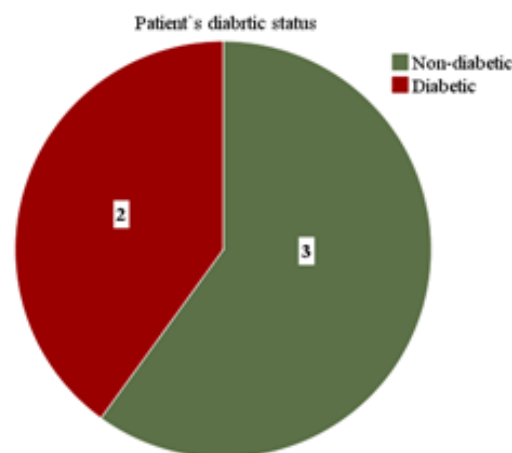


**Sex:** All are male, trauma due to road traffic accident (RTA).

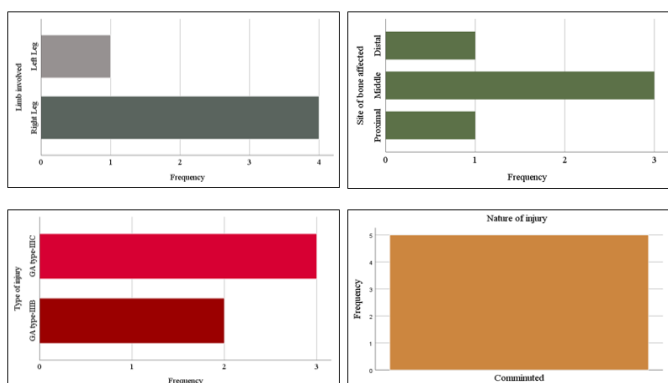
**Medical co-morbidities:** 3 diabetic and 1 hypertensive patients. There were 3 smokers. All of them were walked freely (without assistant of walking aids) before injury (Table 2).

**Table 2** Diabetic status of the patients. (n=5)

| Patient's Diabetes |           |            |
|--------------------|-----------|------------|
|                    | Frequency | Percentage |
| Diabetic           | 2         | 40         |
| Non-diabetic       | 3         | 60         |
| Total              | 5         | 100        |



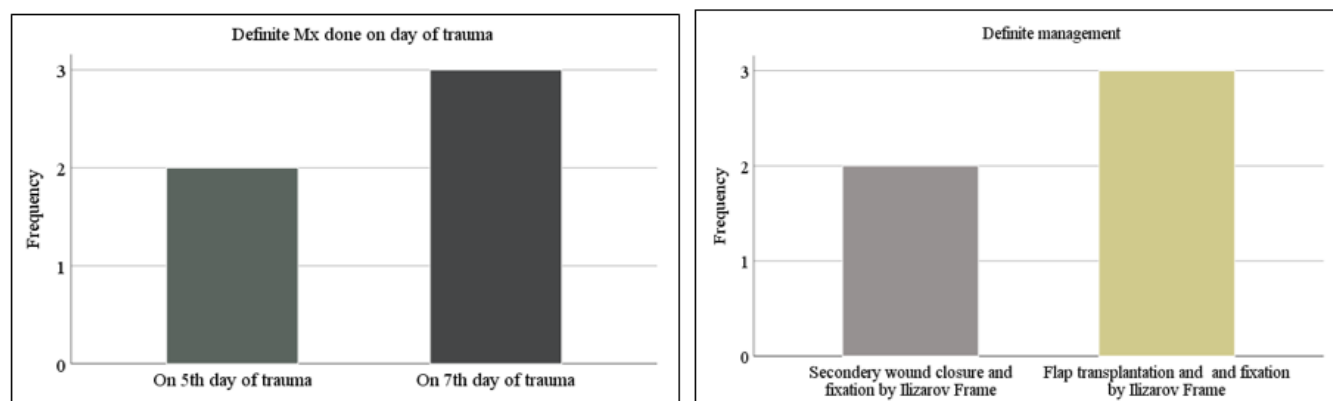
**Injury type, pattern, affected limb and bone site:** There was 2 patients of type-IIIA and 3 type-IIIB with severely contaminated and comminution. No neurovascular damage. Right leg affected of 4 and left leg 1 patient. Proximal tibial shaft involve of injury-1, mid shaft-3 and distal shaft-1 (Figure 1).



**Figure 1** Types of Injury and pattern

**Patient's management:** All 5 patients came in emergency department within 6 hours after trauma. All of 5 patients used NSAIDs during treatment. Each of them stabilized first and given necessary emergency treatment as per standard protocol. Surgical toileting, wound debridement and posterior slab immobilization done as immediate management by orthopedic surgeon. On successive days wound dressing was done every alternative day. Definite management was done by Ilizarov on 5<sup>th</sup> and 7<sup>th</sup> day of trauma. Secondary wound closure given in type-IIIA and vascularized fascio-cutaneous flap transplantation with skin grafting done of type-IIIB cases on same day by orthopedic and flap surgeon (Figure 2).

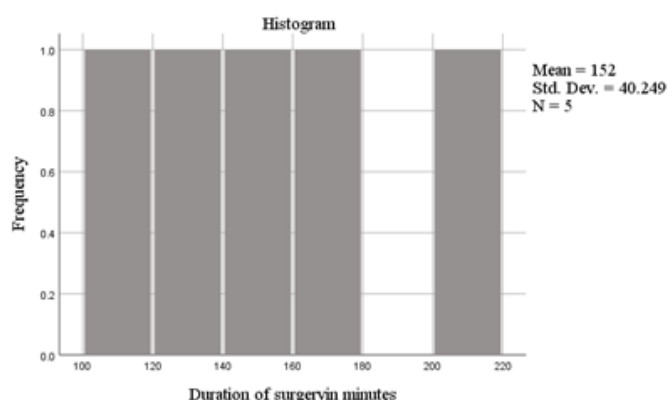
**During surgery:** Surgery was 110-210 minutes. The mean duration ( $\pm$ SD) was 152 ( $\pm$ 40.249) minutes. Blood loss 150-300 ml. The mean amount of blood loss ( $\pm$ SD) was 226 ( $\pm$ 67.305) ml. Tourniquet was used during operation (Table 3, 4).



**Figure 2** Patients management

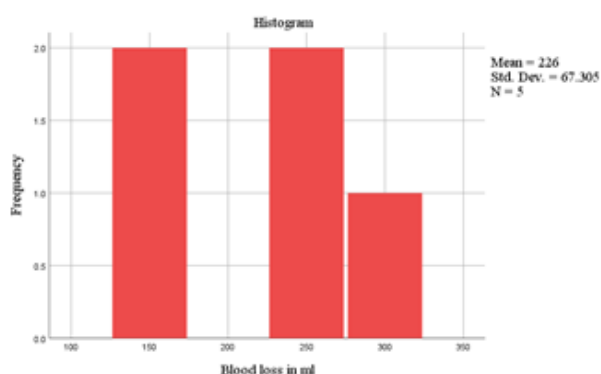
**Table 3** Duration of surgery in minutes. (n=5)

| Surgery duration: |        |
|-------------------|--------|
| Mean              | 152    |
| Std. Deviation    | 40.249 |
| Minimum           | 110    |
| Maximum           | 210    |



**Table 4** Blood loss duration of surgery in ml. (n=5)

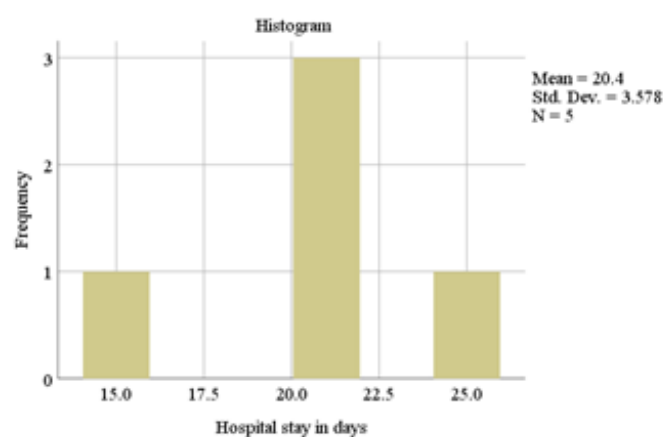
| Blood loss:    |        |
|----------------|--------|
| Mean           | 226    |
| Std. Deviation | 67.305 |
| Minimum        | 150    |
| Maximum        | 300    |



**Post-operative and follow up periods:** 1 patient found superficial skin infection, treated by antibiotic and dressing, also 1 patient's occurred flap edge necrosis, which was managed by debridement and 2<sup>nd</sup> time skin graft. Hospital stays 15-25 days. Union time was 5-7 months. Final outcomes all of 5 patients were excellent (Table 5, 6).

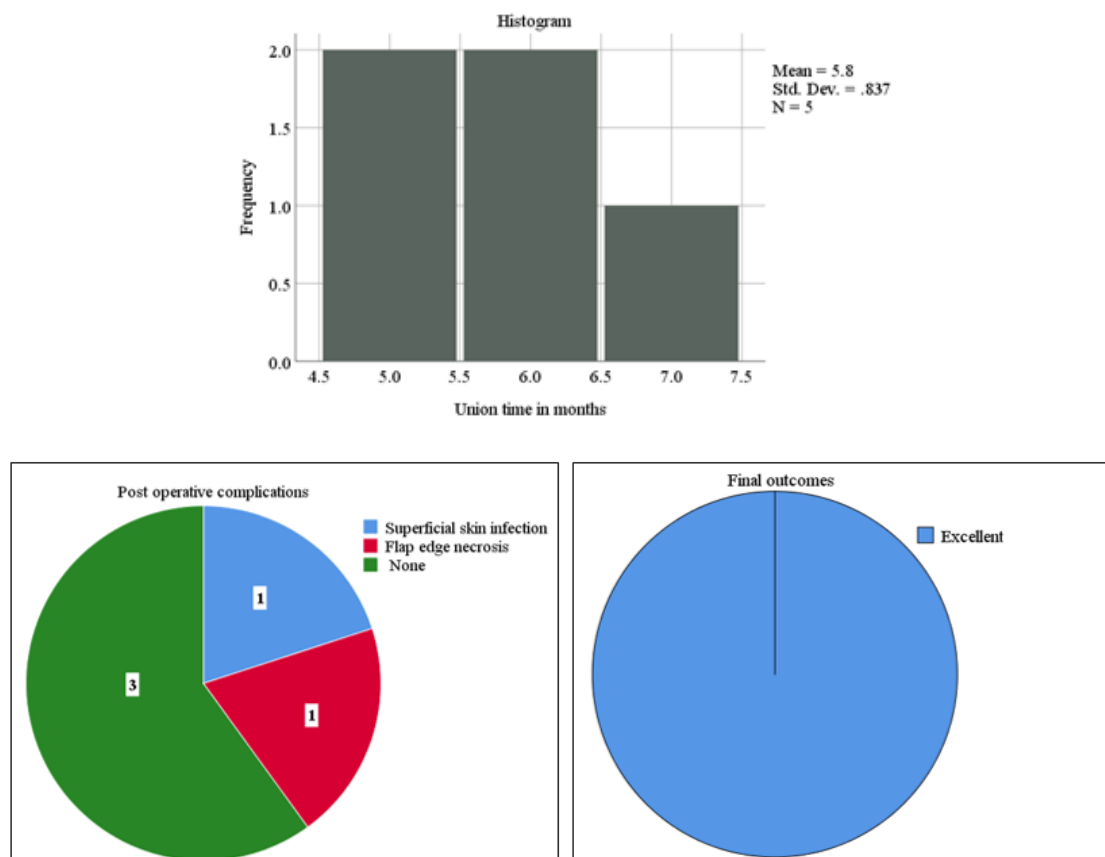
**Table 5** Hospital stay period in days. (n=5)

| Hospital stay: |       |
|----------------|-------|
| Mean           | 20.40 |
| Std. Deviation | 3.578 |
| Minimum        | 15    |
| Maximum        | 25    |



**Table 6** Bone union time in months. (n=5)

| Union time:    |       |
|----------------|-------|
| Mean           | 5.80  |
| Std. Deviation | 0.837 |
| Minimum        | 5     |
| Maximum        | 7     |



## Discussion

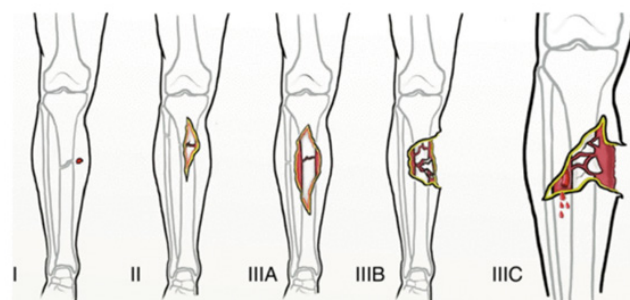
Trauma is the main leading cause of morbidity and mortality in developing countries as well as worldwide. It has great impact both physical and psychological in patients, families and society. Treatment and rehabilitation costs of trauma are excessive, which sometimes bring the person and family into road. The trauma costs are about \$100 billion and more than 150,000 deaths per year.<sup>5</sup> RTA is the major cause of death among young peoples, below the age group 50.

Worldwide around 50 million casualties, which occupying 30-70% orthopedics beds and 1.2 million deaths occurred per year due to RTA.<sup>6</sup> A statistical survey shows during the period of 1998-2003, in Bangladesh average RTA was 3,738, injuries 4,058 and death 3,233 in every year (Figure 3).<sup>7</sup>



**Figure 3** Illustrations of Road Traffic Accident (RTA): [Source internet]

Lower limb injury is commonly sports related, which is affect children and young adults age 5-24 years.<sup>8</sup> Tibia fractures contribute 3.8% of all adult fractures and tibia diaphysis fracture is the commonest long bone fracture.<sup>9</sup> Tibial shaft fractures are approximately 67% and open tibial fractures are about 23.5% (Figure 4).



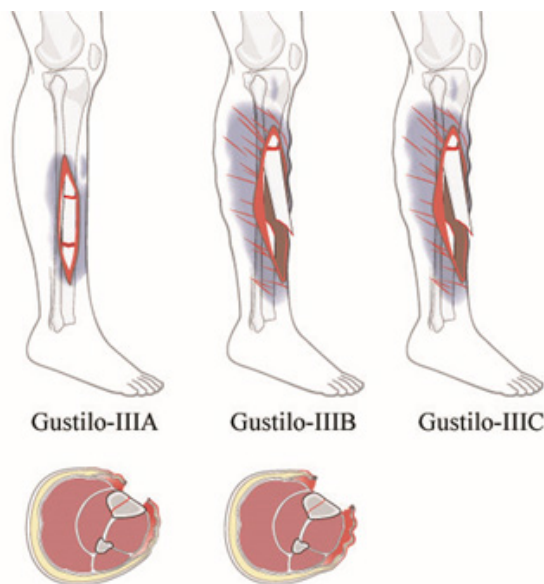
**Figure 4** Illustrations open tibia fracture of Gustilo classifications [Source: Internet].

The cause of injury is high energy trauma, mainly RTA, which is 53.5%. Young males are mostly affected. Over 73% of all RTA injuries were undergoing to men.<sup>10</sup> In our study, 100% trauma was caused by RTA and all patients were male. Young peoples are mostly sustained to trauma due to their activities. Older peoples when fall in injury are more fatal due to pre injury co-morbidities and invariable require ICU support. In this study patient's age 30-65 years, mean ( $\pm$ SD) was 43 ( $\pm$ 13.766). G.I.Nambi, in 2015 described the mean age of GA type-IIIA/B open tibia fracture was 41 years.<sup>11</sup> Medical co-morbidities were diabetic-3 (60%) and 01 hypertensive patients.



There were 3 (60%) smokers. All of them were walked without assistant of walking aids before injury. BMI > 40 and diabetes are the influencing factors of non-union. Diabetes mellitus is closely related to obesity. Obesity can lead to vitamin D deficiency and there is a causal relationship between fracture non-unions.<sup>12</sup> Smoking has an adverse effect on bone physiology, leading to decreased bone mineral density and increased incidence of osteoporotic fractures. Nicotine is a powerful vasoconstrictor causing reduction in peripheral blood flow causes poor bone healing.<sup>13,14</sup>

All patients came in emergency department within 6 hours after trauma. Infection in type-III open fracture was observed 10-50% of the time.<sup>15</sup> Each of them stabilized first and given necessary emergency treatment as per standard protocol. Surgical toileting, wound debridement and posterior slab immobilization done as immediate management by orthopedic surgeon. Wound debridement <48 hours, the infection rate is 20% and >48 hours it is 60%.<sup>4</sup> On successive days wound dressing was done every alternative day. The patients were used NSAIDs during treatment. A significant association between the use of NSAIDs or opioids with non-union of long bone shaft fractures. The pain caused by fracture non-union of patients led to their resorting to NSAIDs. Some experiments have proved that NSAIDs can temporarily inhibit the process of fracture union (Figure 5).<sup>16-18</sup>



**Figure 5** Illustrations of Gustilo – type III open tibia fracture classification [Source: Internet]

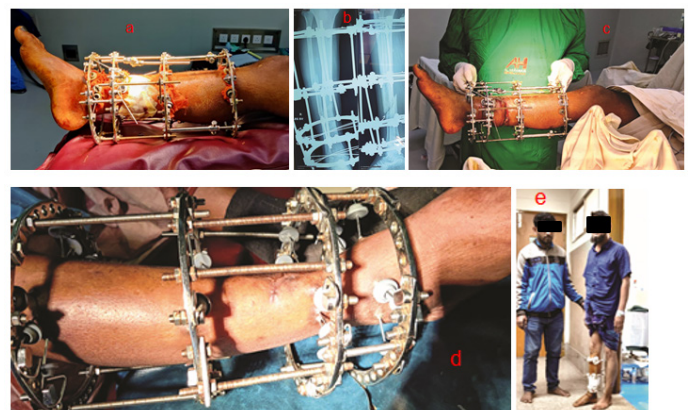
Final diagnosis was made as per Gustilo-Anderson open fracture classification.<sup>9</sup> There were 2 patients of type-IIIA and 3 type-IIIB with severely contaminated and comminution. No neurovascular damage. According to an epidemiological survey >60% of open fracture are type-III.<sup>14</sup> Leg affected right 80% and left 20%. Injury involved proximal tibial shaft 20%, mid shaft 60% and distal shaft 20%. Other study describes fractures patterns are mostly comminuted (25.7%) and mid shaft of tibia are mostly affected (14.3%).<sup>4</sup>

Previously, primary amputation was done in severely injured leg. Secondary amputation of the limb predominated among the patients of Gustilo-Anderson type-IIIB open tibial fracture was-25% and type-IIIC-75% due to serious complication like-infection, soft tissue loss and neuro-vascular damage.<sup>1</sup> GA type-III open tibial fracture associated with others long bone fracture is about 2.9%.<sup>4</sup> Now various studies suggested that salvage is a cost benefited strategy that provides

a better quality of life than amputation.<sup>1</sup> Combined orthopedics, plastic and vascular surgery provides more options for reconstructing the injured limb of Gustilo-Anderson type-III open tibia fracture.<sup>1,11</sup> The treatment of the fracture is fixation by IMN, plate and external fixator with or without fascio-cutaneous flap transplantation. Rigid fixation and good soft tissue coverage are essential for management of the fracture. In IIIA, primary closure done-35.7% and secondary closure-21.4%, IIIB, secondary closure done-44.4%, skin graft-27.8% and flap-27.8% and IIIC, flap done-3%.<sup>4</sup> Reamed nailing is the choice of open tibia fracture treatment with less contamination and fragment comminution. Application of external fixation has great success rate. Ilizarov is a special type of external fixator, provide multi plenary plan of action to manage type III open tibia fractures.

### 70 years male, Gustilo-IIIB open fracture tibia due to MVA. Treated by Ilizarov with flap transplantation.

Figure 6



**Figure 6** a. After Ilizarov fixation, b. Postoperative x-ray, c. Ilizarov reconstruction, d. Picture of wound healthy, e. Full weight bearing after bone fixation.

Soft tissue injuries have been managed by different methods.<sup>1,4,11,20</sup>

1. Suturing: i) Delayed primary closure after 3-5 days, ii) Secondary closure
2. Split thickness skin grafting and
3. Flap transplantation: i) Facio-cutaneous flap, ii) Sural flap, iii) Propeller flap, iv) Adipo-fascial flap, v) Pedicle muscle flap, vi) Free perforator flap and vii) Free muscle flap. It may be ipsilateral or cross leg flap.

The protocol commonly follows for flap transplantation are:

- a) Gastrocnemius muscle flap for upper leg
- b) Soleus muscle flap for middle leg and
- c) Reverse sural fascio-cutaneous flap or free tissue transfer for lower leg defects.

Selection of a pedicle or muscle flap depends on the nature of injury and the location of leg. There were different opinion and works for bone fixation and soft tissue coverage in GA type-III open tibia fracture. G.I.Nambi, in 2015 described, bone fixation done immediately after debridement but soft tissue coverage is not performed because high incidence of bone infection and major flap complications. Also he was performed wound debridement, bone fixation and flap coverage within 8-14 hours of trauma. A. Alsultan,

in 2022 described, reconstruction should perform within 24 hours due to high rate of infection. T. G. Ugwuowo described in 2021, skin graft and flaps were done on 14<sup>th</sup> post injury day. It is more difficult to rescue the injured limb with failed flap surgery (Figure 7).



**Figure 7** 65 years, male of type IIIB comminuted and severely contaminated open tibial fracture (Right), managed by Ilizarov with posterior tibial artery, perforator based proximal fascio-cutaneous flap.

We performed definite management by Ilizarov on 5<sup>th</sup> and 7<sup>th</sup> day of trauma. All of the cases in our study were severely contaminated and comminution. So, we wait for healthy wound and free from infection. Secondary wound closure was given in type-IIIA and vascularized fascio-cutaneous flap transplantation with skin grafting done of type-IIIB cases on same day by orthopedic and flap surgeon. We were managed with proximally based fascio-cutaneous flap for upper and middle leg defects, the lower leg defects managed with reverse sural flap. Ilizarov frame fixation with secondary closure and flap transplantation is a single stage definite management of GA type-III open tibia fracture, which provides excellent outcomes, early mobilization and infection control, as well as reduce treatment cost, patient's mortality and morbidity rate.

Surgery duration was 110 -210 minutes, mean ( $\pm$ SD) 152 ( $\pm$ 40.249). Blood loss was 150-300 ml, mean ( $\pm$ SD) 226 ( $\pm$ 67.305).

**Table 7** Final results of the patients. (n=5)

| Patients  | ASAMI bone                                    | ASAMI Function                           | RUST Score | Paley deformity type |         |         | Follow up duration (Months) | Union time (Months) | Final outcomes |
|-----------|-----------------------------------------------|------------------------------------------|------------|----------------------|---------|---------|-----------------------------|---------------------|----------------|
|           |                                               |                                          |            | Paley-1              | Paley-2 | Paley-3 |                             |                     |                |
| Patient-1 | Union, no infection, No angulation & No LLD   | Active, no limp, ROM within normal range | 12.0       | No                   | No      | No      | 5                           | 5                   | Excellent      |
| Patient-2 | Union, no infection, Angulation-5° & No LLD   | Active, no limp, ROM within normal range | 10.4       | No                   | No      | No      | 5                           | 5                   | Excellent      |
| Patient-3 | Union, no infection, No angulation & No LLD   | Active, no limp, ROM within normal range | 10.8       | No                   | No      | No      | 6                           | 6                   | Excellent      |
| Patient-4 | Union, no infection, No angulation & No LLD   | Active, no limp, ROM within normal range | 10.6       | No                   | No      | No      | 6                           | 6                   | Excellent      |
| Patient-5 | Union, no infection, No angulation & LLD-1 cm | Active, no limp, ROM within normal range | 10.2       | No                   | No      | No      | 7                           | 7                   | Excellent      |

Tourniquet was used during operation in all cases. Infection is the major complication and the rate is 28.6% in IIIA, 44.4% in IIIB and 100% in IIIC open tibial fracture.<sup>4</sup> In our cases, 1 patient's found superficial skin infection, treated by antibiotic and dressing, also 1 patient's occurred flap edge necrosis, which was manage by debridement and 2<sup>nd</sup> time skin graft. Duration of hospital stay 2-6 weeks of IIIA, 3-8 weeks of IIIB and 6-10 weeks of IIIC.<sup>12</sup> In our cases hospital stays 15-25 days, mean ( $\pm$ SD) 20.40 ( $\pm$ 3.578). The range of soft tissue healing was 7-150 days, median time 14 days.<sup>21</sup> In this study soft tissue healing range 3-6 weeks. Full weight bearing was given on 3<sup>rd</sup> POD.

All patients was came follow up at regular interval, weekly for 1 months then monthly up to bony union. Union time was defined as the time from injury to radiological follow up found a RUST score of 10 or more.<sup>21</sup>

### RUST score criteria

| Score per cortex* | Radiographic criteria |               |
|-------------------|-----------------------|---------------|
|                   | Callus                | Fracture line |
| 1                 | Absent                | Visible       |
| 2                 | Present               | Visible       |
| 3                 | Present               | Invisible     |

\*The individual cortical scores (anterior, posterior, medial and lateral) are added to

provide a RUST value ranging from 4 to 12 with 10 or greater, representing a healed fracture.

J. Steele describe in 2019, GA type-III open tibia fracture average union time was 5.8 months and average RUST score was 10.3 (Range 8-12). At final follow up x-ray we found RUST score 10.8 (Range 10-12). Union time was 5-7 months, mean ( $\pm$ SD) 5.80 ( $\pm$ 0.837). Final outcomes of all patients were excellent according to ASAMI score and as per Paley's classification, there were no deformity (Table 7).

## Summary

Full weight bearing was given on 3<sup>rd</sup> POD. All patients were followed up at regular interval. The range of soft tissue healing was 3-6 weeks. There was 1 patient's found superficial skin infection, treated by antibiotic and dressing, also 1 patient's occurred flap edge necrosis, which was managed by debridement and 2<sup>nd</sup> time skin graft. Bone union time was 5-6 months, RUST scores found at final follow up 10.8. After complete union and consolidation, we assess results according to ASAMI score, there were all excellent results. As per Paley's classification, there were no deformity. We were successfully managed all cases by Ilizarov with secondary closure and fascio-cutaneous flap transplantation.

## Conclusion

RTA is the main cause of type III open tibial fractures in Bangladesh. Combined multi-disciplinary managements by Ilizarov with secondary closure and vascular fascio-cutaneous flap transplantation provide excellent outcomes, early mobilization and infection control. It is a single stage definite management, which reduce treatment cost, patient's mortality and morbidity.

## Limitations

Sample size are too small, less patient's information in data base and patients was not regular in follow up.

## Consent

We were taken informed written consent from all patients and patient's family for publishing in all media.

## Acknowledgements

We are the authors declared; not taken benefits from others directly or indirectly.

## Conflict of interest

The authors declare no conflicts of interest.

## Authors contributions

C. F. Rob was contribute in writing and editing the manuscript and J. Hossain was contribute in writing and editing the manuscript, literature reviews, analyzed and interpreted data regarding the article.

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