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TRAUMA SURGERY

One-stage combined "fix and flap" approach for complex open Gustilo–Anderson IIIB lower limbs fractures: *a prospective review of 102 cases*

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Abstract

Background Management of open fractures is challenging and requires a multidisciplinary team approach. This study aims to evaluate outcomes of open Gustilo–Anderson IIIB fractures managed at a single Ortho-Plastic centre following One-stage "Fix and Flap" approach.

Methods Prospective data review for patients presenting with Gustilo–Anderson IIIB Fractures to our centre and managed with one-stage "Fix and Flap" approach. Postoperative outcomes are presented only for the patients who had a minimum of 12 months postoperative follow-up.

Results 120 patients were included (83 males and 37 females). Mean age was 43 years (10–96). Tibia diaphysis was the most common site of injury (60%). 55.9% of injuries were road traffic accidents (RTA). 102 out of 120 patients had a minimum of 12 months follow-up (mean follow-up duration 25 months). Meantime from injury until definitive surgery was 7.71 days. Primary union achieved in 86.73%. Delayed union was encountered in 10.20%. 3.06% of patients had non-union. Limb salvage rate was 97.05% and Deep infection rate was only 0.98%.

Conclusion Our results showed that low infection rate, high limb salvage rate, and high union rate can be achieved in these complex injuries with meticulous technique, combined Ortho-Plastic (Fix and Flap) approach, and MDT input.

Keywords Open fracture · IIIB · Gustilo–Anderson · One-stage · Ortho-plastic · Fix and flap

Introduction

Open fractures are severe injuries resulting from high energy trauma [1–3]. Open long bone fractures had been reported to affect 11.5 per 100,000 population per annum [4]. These injuries are associated with significant soft tissue damage and can be life- or limb-threatening [1]. Gustilo and Anderson classified open fractures into 3 main categories based on wound size, level of contamination, severity of soft tissue/bony injuries [5, 6] (Table 1). This classification provides prognostic value with greater risk of complications (infection, delayed union, non-union, or amputation) in higher grades of injury [6–8].

Gustilo IIIB fractures are the most severe type and ideally requires combined soft tissue cover and skeletal stabilisation by Plastics and Orthopaedics surgeons [1]. Higher rate of complications had been reported following these injuries compared to the other lower grades of open fractures [9]. A systemic review and meta-analysis conducted by Papakostidis et al. 2011 showed 80% risk of delayed union in IIIB fractures compared to 10.4% in type I fractures. Deep infection rate was as common as 36% in patients with IIIB fractures, which was ten times higher

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Table 1 Gustilo–Anderson Classification of Open Fractures [5, 6]

Gustilo–Anderson fracture grade	Description
Type I	Clean open fracture with less than 1 cm wound
Type II	1–10 cm laceration, with moderate soft tissue damage
Type IIIA	More than 10 cm wound with adequate soft-tissue coverage despite extensive laceration
Type IIIB	Severe form and is associated with a significant soft tissue loss of more than 10 cm that needs cover
Type IIIC	open fracture associated with arterial injury requiring repair

than its rate in comparison to patients with type I fractures (3.36%). Amputation rate was as high as 17.6% [9].

Combined ortho-plastic approach for management of Gustilo IIIB fractures was recommended by the guidelines published by The British Orthopaedics Association (BOA) and British Association of Plastics, Reconstructive and Aesthetic Surgeons (BAPRAS) in 2017 [10]. This guideline has recommended performing the definitive soft tissue cover within 72 h of injury to minimise postoperative complications including deep infections [11]. Outcomes of Gustilo IIIB fracture have improved after the advent and implementation of a combined Ortho-Plastic approach with one-stage "Fix and Flap" technique to achieve definitive fracture fixation and soft tissue cover in the same sitting [1, 12]. Gopal et al. 2000 reported 95% limb salvage rate, 66% primary union rate, and only 9.5% deep infection rate after reviewing the outcomes of 79 patients with IIIB open fractures managed following such a combined Fix and Flap approach.

More recently, Mathews et al. 2015 compared the Gustilo IIIB open fractures' deep infection rate between patients who had a combined one-stage "Fix and Flap" approach (group 1) and those who had separate procedures (group 2) [13]. Deep infection rate was 4.2% for patients in group 1 compared to 34.6% in group 2 ($P < 0.001$)[13]. On the same context, Wordsworth et al. 2016 reported 1.5% deep infection rate, 94% limb salvage rate, and 89.4% primary fracture union rate following combined Ortho-Plastic "Fix and Flap" approach for patients with Gustilo IIIB fractures [12].

The early outcomes of patients with Gustilo IIIB open fracture had been already previously assessed by two studies published from our centre [14, 15]. The previous two studies indicated low infection rates and high limb salvage rates compared to other published literature. The current study is an extension to the previous series, with a larger patient s' sample and longer duration. We will also review the relationship between anatomical site of injury, comorbidities, time of first debridement, time of definitive wound closure, positive growth from deep tissue samples taken at definitive surgery; and the postoperative outcomes including union rate, infection rate, limb salvage, and re-operation rate.

Materials and methods

Prospective data review for patients admitted to our Ortho-Plastic unit with Gustilo IIIB open fractures between June 2013 and June 2020 was performed. Patients were either direct admission from our Emergency Department (ED) or referred from regional hospitals after initial debridement and provisional stabilisation. We only included patients who had one-stage "Fix and Flap" Ortho-Plastic surgery for Gustilo IIIB open fractures. Postoperative outcomes are presented only for patients with a minimum 12 months follow-up.

On admission to ED, all patients were started on IV antibiotics as per local protocol, which continued until definitive wound closure. Co-amoxiclav (1.2 g) Intra-Venous (IV) three times daily was given to patients who are not allergic to penicillin. 5 mg/kg of IV Gentamicin (reduced to 3 mg/kg in patients with renal impairment) was administered at time of first debridement. Patients with penicillin allergy were given Metronidazole, Teicoplanin, and Gentamicin (age, weight, and renal function appropriate dosage). Multiple (minimum of five) deep bone and soft tissue samples were taken at time of definitive surgery for extended culture and sensitivity following The Oxford protocol [16–18]. All definitive "Fix and Flap" surgeries were conjointly led by a consultant Orthopaedics surgeon and a consultant Plastic surgeon. All cases were discussed in Multidisciplinary Team (MDT) meetings before surgery with active input from Infectious Diseases (ID) consultants.

First debridement, washout, and provisional skeletal stabilisation were performed for all patients on the next available trauma list (unless urgent procedure was indicated, such as severe contamination, or compartment syndrome). All patients had negative pressure dressing applied after debridement.

The definitive "Fix and Flap" surgery usually starts with thorough debridement, lavage, and final assessment. Meticulous debridement and careful tissue handling are key factors for successful infection prevention. Using contralateral limb as graft donor where possible allows both

teams to work simultaneously to minimise operative time. Postoperatively, patients are observed closely as per the local protocol for vascularity of flap. This includes careful nursing of the limb, which is kept warmed by a Bair Hugger with leg elevated and fluid balance measured. Free flaps are monitored postoperatively until day 4 by colour, temperature, capillary refill, turgor, and Acoustic Doppler Sonography. After 48 h of elevation, the leg is subject to a dangling protocol to gradually increase venous pressures in a dependent position and permit early mobilisation. Follow-up is fortnightly in a combined Ortho-Plastic clinic with input from ID, complex wound nurses, and physiotherapist.

Perioperative data including patients' demographics, site and mechanism of injury, timing of first debridement, timing of definitive Ortho-Plastic (Fix and Flap) surgery, type of skeletal stabilisation, and soft tissue cover were analysed for all patients. Postoperative complications including superficial or deep infections, delayed union, non-union, amputation, and reoperation rates were audited and reviewed. Statistical analysis performed using the Chi-Squared test using Windows Microsoft excel – data analysis pack tool. *P* value of $< 0.05\%$ considered to be significant. All tables were produced using Microsoft Word 2019. Figures were designed using either Microsoft excel 2019, or Microsoft Power point 2019. A 12 months minimal follow-up filter was applied when we analysed the outcome data to maximise the chance for capturing postoperative complications.

Results

Data of 120 patients (83 males, 37 females) with Gustilo IIIB fracture presented to our unit were reviewed. Patients' mean age was 43 (10–96). One third of patients (36.6%) were active smokers at time of injury. Patient comorbidities are summarised in Fig. 1.

Road traffic accidents (RTAs) were the most common mechanism of injury (55.9%). The other mechanisms of injury are summarised in Fig. 2. Tibial diaphyseal fractures were the most common (60%). Details about the anatomical site of injury are summarised in Fig. 3.

Ortho-plastics approach

The mean time from injury to first debridement was 11.53 (3–48) h. This was within 12 h in 61 patients (50.83%), between 12 and 24 h in 57 patients (47.5%), and between 24 and 48 h in 2 patients (1.67%). The mean time from injury until definitive "Fix and Flap" surgery was 7.71 (1–30) days. Thirty-two patients (26.6%) had their surgery within 72 h from injury, 76 patients (63.3%) within 7 days, 106 patients (88.33%) within 14 days, while the remaining 14 patients had their surgery after 14 days. This delay was either related to patients' medical optimisation, delay in transfer from local hospitals, or due to unavailability of combined Ortho-Plastics expertise.

Definitive skeletal stabilisation and soft tissue reconstruction depended on severity of soft tissue loss, degree of comminution, availability of soft tissue for transfer, and patients'

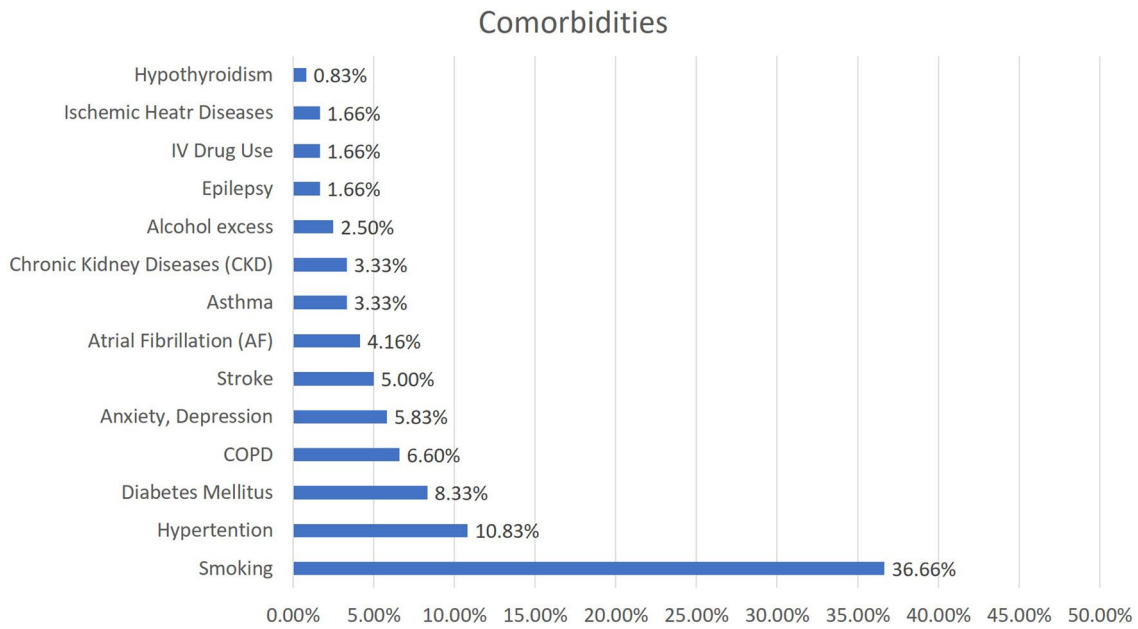

Fig. 1 Patients' comorbidities and smoking status

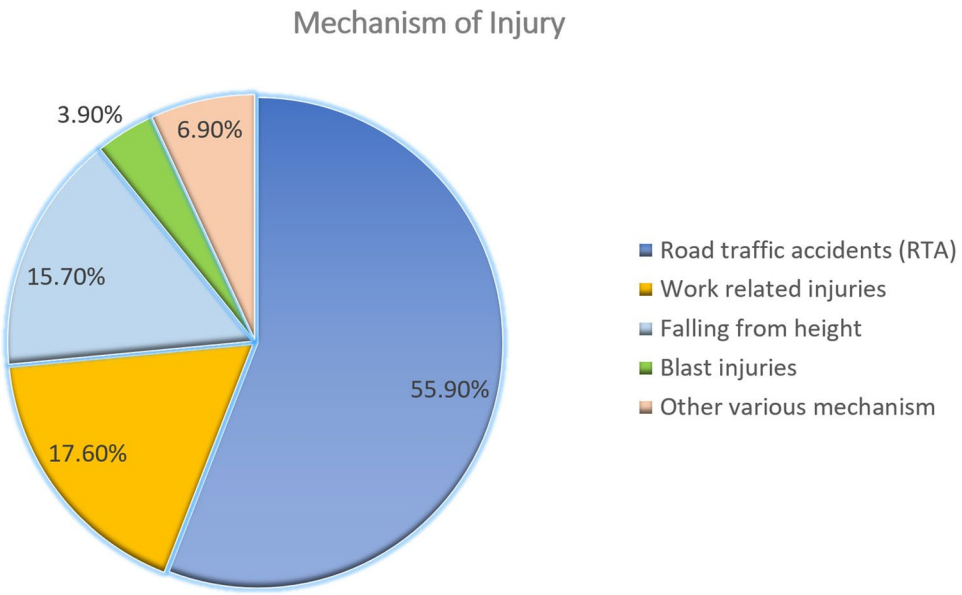

Fig. 2 Pie chart summarising the mechanisms of injury (%)

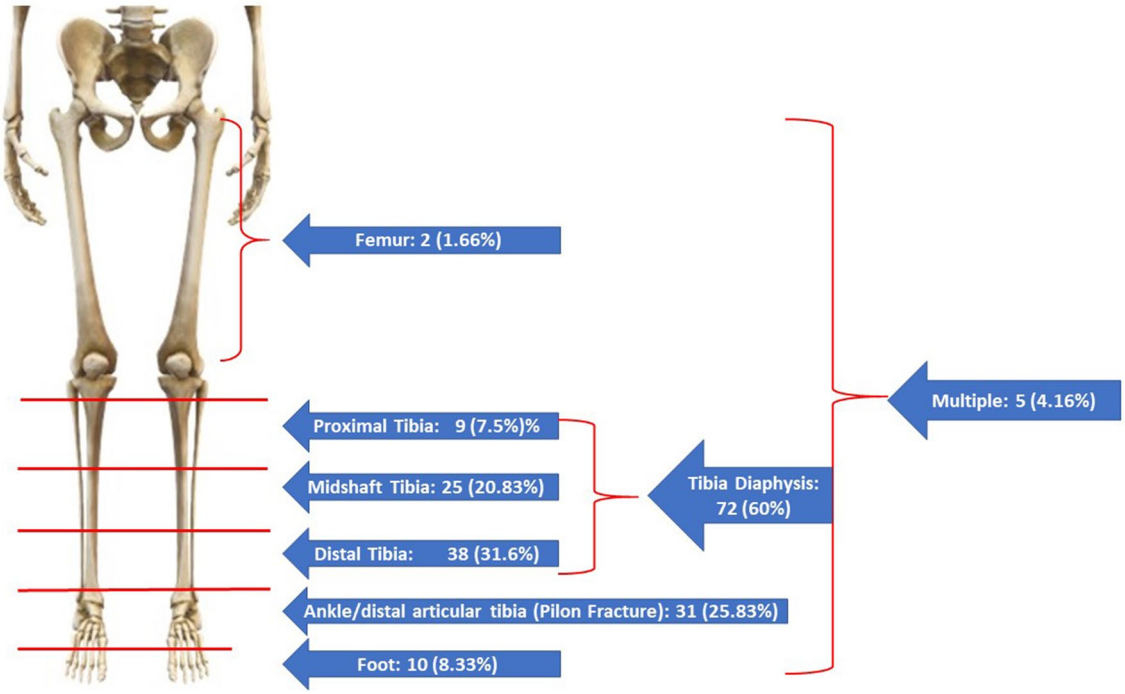

Fig. 3 Anatomical site of injury (%)

medical condition. Open Reduction and Internal Fixation (ORIF) using compression/anatomical plate was the most common method of skeletal stabilisation (35.83%). Techniques of skeletal stabilisation are summarised in Table 2.

Free Antero-Lateral Thigh (ALT) Flap was the most common definitive wound cover technique (40.83%). Table 3 summarise type of soft tissue cover. Local Antibiotics in Calcium Sulphate carrier (Cerament G) used in 88 out of 120 patients (73.33%) as a void filler due to significant bone loss/large voids.

Microbiological results at the time of the definitive surgery

Positive growth was obtained from culture results of the deep samples taken at definitive surgery in 31 patients

Table 2 Method of definitive skeletal stabilisation

Method of fixation	Number (%)
Plate and screw (ORIF)	43 (35.83%)
Intramedullary (IM) Nail	29 (24.16%)
Circular Frame (Ilizarov / Taylor Spatial Frame (TSF)	21 (17.5%)
External Fixation (Monolateral Fixation)	8 (6.67%)
Internal fixation supported by External Fixation	9 (7.5%)
Various methods (e.g. Malleolar screws or Kirschner wires)	10 (8.34%)
Total	120 (100%)

Table 3 Type of soft tissue cover at time of definitive surgery

Type of soft tissue cover	Number (%)
Free Anterolateral Thigh (ALT) Flap	49 (40.83%)
Local Rotational Flap	46 (38.33%)
Latissimus Dorsi Flap	4 (3.34%)
Other forms, such as Split Thickness Skin Graft	21 (17.5%)
Total	120 (100%)

(25.83%). Twenty patients (16.66%) had single pathogen, whereas polymicrobial growth was confirmed for the remaining 11 (9.16%). *S aureus (SA)* was the most common (isolated in 14 patients), Fig. 4 summarise the results of deep tissue samples.

Postoperative outcomes, final follow-up

102 patients had a minimum of 12 months follow-up. The mean follow-up time was 25 (12–45) months. 3 patients died within one year after the definitive procedure from conditions unrelated to surgery. Primary bone healing was confirmed in all of them within the follow-up duration, with no reported complications. Three patients required amputation and were excluded from calculation of fracture union rate. One patient was lost in follow-up, the latest radiograph he had at 4 months postoperatively showed evidence of progressing bony union. This patient was excluded from the union rate calculation. This resulted in 98 patients been assessed for bone union.

Fracture union

Primary bone healing achieved in 85 (86.73%) patients at a mean of 32 (15–73) weeks. Ten (10.20%) patients had delayed union evidenced by minimal radiological progression of bone healing at 9 months postoperatively. Fracture healing in these 10 cases was stimulated by Autologous Bone Marrow Aspirate Concentrate (BMAC) injected to the fracture site by using Biomet® Bone Marrow Stem harvesting system. Successful fracture healing conformed in all of them at 21 (17–26) weeks after BMAC injection. Non-union was confirmed in 3 (3.06%) patients, with no evidence of fracture healing at one year after definitive surgery. All these patients had a circular frame at initial surgery which was revised into internal fixation supplemented by autologous

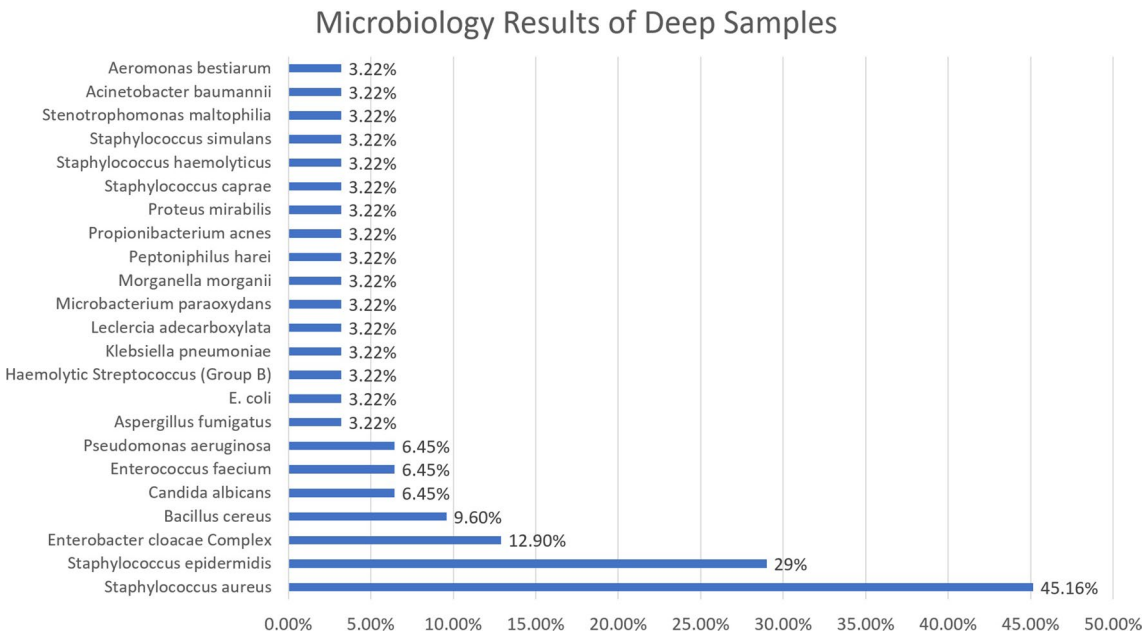

Fig. 4 Microbiology results of the patients who had positive growth from the deep samples taken at time of definitive surgery

cancellous bone graft in a combined Ortho-Plastic sitting. Deep tissue samples at time of the initial Ortho-Plastic surgery for these 3 patients had initially shown positive culture in 2 of them (*morganella, pseudomonas;* and *SA*). Deep samples taken at time of revision surgery, however, was negative for all 3. Our results showed no statistically significant correlation between bone union rate and anatomical site of injury, smoking, diagnosis of diabetes, time between injury and first debridement, time between injury and definitive procedures, or positive growth from deep samples taken at definitive surgery (Table 4).

Infection rate

Superficial wound infection reported in 32 (31.37%) patients in a mean time of 5.8 (1–30) months postoperatively. Single pathogen was isolated in 21 (20.58%) patients, whereas polymicrobial growth was reported in 11 (10.78%) patients. *SA*. was the most common microorganism isolated in 18 of 32 patients (56.25%) (Fig. 5). All wound infections were treated successfully with antibiotics as per sensitivity and microbiology advice.

Only 10 of 32 patients who had superficial wound infection had positive growth from the deep samples taken at the definitive surgery. Only two of these 10 (20%) had the same microorganism isolated from both deep tissue sample at definitive surgery and the culture and sensitivity results for superficial wound infection.

Our results show no statistically significant correlation between superficial wound infections and anatomical site of injury, history of smoking, diagnosis of diabetes, time between injury and first debridement, time between injury and definitive procedure, or positive growth from deep samples taken at definitive surgery (Table 5).

One patient (0.98%) had deep infection at 5 months after surgery that necessitated a revision surgery with removal of implant. She was 55 years old female with multiple comorbidities (Type 2 diabetes, alcohol excess, smoking, asthma, and recurrent pleuritis). She had right foot Gustilo IIIB open fracture, the first debridement was performed within 12 h, followed by definitive ORIF and free ALT flap at 3 days after injury. Her deep tissue samples from the definitive surgery demonstrated no growth. She had revision surgery at 5 months postoperatively with removal of implant, debridement, application of local antibiotics (Cerament G). The deep bone and soft tissue samples at the revision surgery showed positive growth for *SA* treated successfully with 6 weeks of IV antibiotics with no recurrence.

Limb salvage

Three patients required amputation at a mean of 4.6 weeks following the definitive surgery, resulting in 97.05% limb salvage rate. Two of them presented with extensive soft tissue loss and amputation was indicated within 2–4 weeks of the definitive surgery due to flap failure and the severity of soft tissue loss. The third patient had postoperative flap congestion and necrosis, the limb was unsalvageable and was amputated at 8 weeks postoperatively. There was no statistically significant correlation between limb salvage rate and

Table 4 Fracture union rate and its relation to the patients' medical conditions and perioperative factors

	Fracture union				
	Primary union	Delayed union	*P* value	Non-union	*P* value
Mean age (years)	44.9	30		38.6	
Smoker (%)	32 (37.64%)	6 (60%)	*0.1723083*	1 (33.3%)	*0.8794400*
Diagnosis of Diabetes	10 (11.76%)	0%	*0.251513*	0%	*0.5280254*
Growth from deep tissue sample at time of definitive surgery	27 (31.76%)	2 (20%)	*0.44477497*	2 (66.7%)	*0.206241337*
Anatomical site of injury					
Ankle	20 (23.52%)	2 (20%)	*0.802382106*		
Tibia Diaphysis	51 (60%)	8 (80%)	*0.217511229*	3 (100%)	*0.161989442*
Foot	7 (8.23%)				
Multiple	5 (5.88%)				
Femur	2 (2.35%)				
Time form injury till first debridement					
< 12 h	47 (55.3%)	6 (60%)		2 (66.7%)	
> 12 h	38 (44.7%)	4 (40%)	*0.776845266*	1 (33.3%)	*0.69675276*
Mean time form injury till the definitive Ortho-Plastic surgery					
< 72 h	20 (23.53%)	4 (40%)		1 (33.3%)	
> 72 h	65 (76.47%)	6 (60%)	*0.256868453*	2 (66.7%)	*0.695406077*
Number of patients	85	10		3	

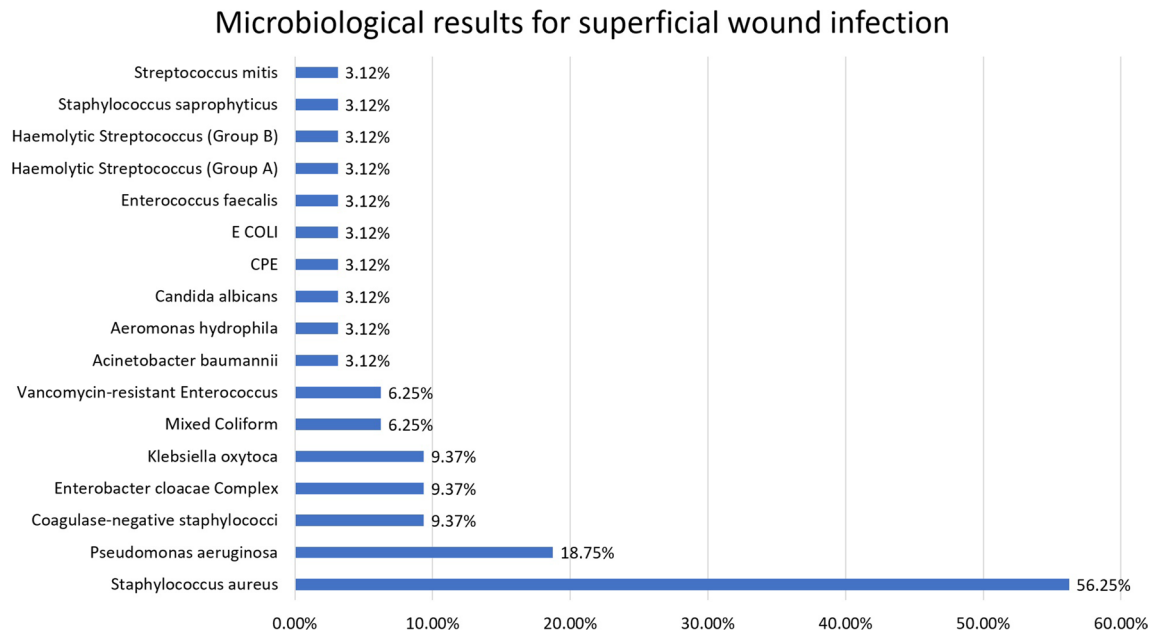

Fig. 5 Microbiological results of the patients with superficial wound infection

anatomical site of injury, smoking, diagnosis of diabetes, time between injury and first debridement, time between injury and definitive procedure, or positive growth from deep samples taken at definitive surgery (Table 5).

Revision procedures

Revision surgical procedures were required in 20 (19.6%) patients (10 for delayed union, 3 non-union, 6 for flap related complications, and 1 deep infection). No statistically significant correlation was noticed between reoperation rate and anatomical site of injury, smoking, diagnosis of diabetes, time between injury and first debridement, time between injury and definitive procedure, or positive growth from deep samples taken at definitive surgery (Table 5). Flap complications included necrosis, congestion, wound dehiscence, or total flap failure were reported in 36 patients (35.3%).

Discussion

Open fractures associated with more than 5 cm soft tissue injuries are well known as a great challenge to Orthopaedics and limb reconstruction surgeons, and staged approach for the management of these injuries is gaining more popularity [19, 20]. Treatment of open fracture includes radical debridement to remove damaged, devitalised tissue and bone fragment, wound washout, fractures stabilisation, IV antibiotics, and wound closure [14, 21]. Gustilo IIIB open fractures are associated with high rates of complications. Infection is one of the major complications that may result in non-union, permanent loss of function, decreased quality of life, or even amputation [22, 23]. Historical reports suggested up to 52% deep infection rate, 16% risk of amputation and 50% non-union rate [6, 9]. However, by following one-stage "Fix and Flap" approach, better outcomes had been reported with lower infection rate, high limb salvage and high union rates [1, 12, 13]. This study results show a consistent outcome for patients with Gustilo IIIB open fractures presented to our centre. At a mean follow-up of 25 months, our results showed low deep infection rate, high union and limb salvage rates, and low reoperation rate can be achieved in patients with Gustilo IIIB open fracture. To our knowledge, this is the largest published series that assess the long-term outcomes of patients with Gustilo IIIB open fracture who had One-Stage "Fix and Flap" approach under combined Ortho-Plastic team.

Union rate and limb salvage

Primary bone union achieved in 86.73% of patients at 32 weeks. Ten patients (10.20%) had delayed union, and fracture healing was stimulated by BMAC injected into the fracture site. BMAC is rich in stem cells with potential to differentiate into different musculoskeletal cells, including osteoblast [24]. A systemic review conducted by Imam et al. showed successful fracture union in 89% of patients who had BMAC for fractures non-union within 8 months following the procedure [24]. Our results showed that successful fracture union can be achieved in open fractures with BMAC

Table 5 Incidence of: superficial wound infection, revision surgery and limb salvage rate and their relation to the patients' medical conditions and perioperative factors

	Superficial wound infection			Revision surgery			Limb salvage		
	Patients with superficial wound infection	Patients without superficial wound infection	*P* value	Patients who had revision	Patient who had no revision	*P* value	Patients who had amputation	Patients with salvaged limbs	*P* value
Mean age (years)	41.75	43.95		41.7	43.86		39.3	43.57	
Smokers (%)	14 (43.7%)	25 (35.71%)	*0.438398*	11 (55%)	28 (34.14%)	*0.0853*	1 (33.3%)	38 (38.38%)	*0.85924*
Diagnosis of Diabetes	4 (12.5%)	6 (8.57%)	*0.535847*	2 (10%)	8 (9.75%)	*0.9738*	1 (33.3%)	9 (9.09%)	*0.16419*
Growth from deep tissue sample at time of definitive surgery	10 (31.25%)	21 (30%)	*0.898658*	6 (30%)	25 (30.48%)	*0.9661*	1 (33.3%)	30 (30.30%)	*0.91048*
Anatomical site of injury									
Ankle	7 (21.9%)	16 (22.85%)	*0.912303*	4 (20%)	19 (23.2%)	*0.7053*		23 (23.23%)	
Tibia diaphysis	21 (65.6%)	44 (62.85%)	*0.787329*	15 (75%)	50 (61%)	*0.2421*	3 (100%)	62 (62.62%)	*0.18469*
Foot	3 (9.37%)	4 (5.71%)	*0.497426*	1 (5%)	6 (7.3%)	*0.7133*		7 (7.07%)	
Multiple	1 (3.12%)	4 (5.71%)	*0.574119*		5 (6.1%)			5 (5.05%)	
Femur		2 (2.85%)			2 (2.4%)			2 (2.02%)	
Time form injury till first debridement									
< 12 h	13 (40.6%)	42 (60%)		13 (65%)	42 (51.21%)		3 (100%)	52 (52.52%)	*0.10412*
> 12 h	19 (59.4%)	28 (40%)	*0.068527*	7 (35%)	40 (48.79)	*0.2676*	0	47 (47.47%)	
Mean time form injury till the definitive Ortho-Plastic surgery									
< 72 h	7 (21.9%)	18 (25.7%)		8 (40%)	17 (20.73%)		0	25 (25.25%)	
> 72 h	25 (78.1%)	52 (74.3%)	*0.675748*	12 (60%)	65 (79.26%)	*0.0725*	3 (100%)	74 (74.74%)	*0.31645*
Total number of patients	32	70		20	82		3	99	

for delayed union. Three patients had non-union and had a revision Ortho-Plastic surgery. The flap was lifted by the plastic surgeon and the fracture was revised with Autologus Cancellous bone graft inserted to stimulate bone healing.

We have achieved a high limb savage rate where 99 out of 102 limbs were successfully salvaged. Our limb salvage rate is higher than what has been reported in literature. Table 6 compares our results to currently available literature.

Smoking had been reported to affect bone healing in patients with long bone fractures [25]. In the current study, 60% of patients with delayed union were smokers, compared to only 37.64% of patients who had primary union, however, this difference was not statistically significant (*P* value: *0.1723083*). Similarly, diagnosis of Diabetes, or delay in first debridement, or > 72 h delay in having the definitive "Fix and Flap" surgery did not have any significant effect on bone union/limb salvage rate.

Infection rate

There is no consensus in literature regarding timing of first debridement of open fractures after the injury. Werner et al. recommended that the initial debridement should be performed urgently (within 6 h of injury) to decrease the risk of infection [21]. However, Patzakis et al. reported no relation between the risk of developing infection and late

Table 6 Historical Gustilo–Anderson IIIB open fractures outcomes from the literature compared to our study

Study	Number of patients with IIIB open fractures	Follow-up (months)	Deep infection rate (%)	Union rate after the primary surgery (%)	Limb salvage rate (%)	Reoperation (%)
Gustilo et al. 1984 [6]	25	NA	52		84	NA
Gopal et al. 2000 [1]	79	NA	9.5	66	95	NA
Keating et al. 2000 [30]	51	41	17.5	58	92.2	59
Naique et al. 2006 [29]	73	14	8.5	50.6	93	NA
Tielinen et al. 2007 [31]	19	10–119	0	53	NA	47
Rohde et al. 2007 [32]	38	NA	18.4	71	94	36.8
Mathew et al. 2015 [13]	74	12	14.9	NA	91.9	NA
Wordsworth et al. 2016 [12]	66	40	1.5	89.4	94	NA
Doshi et al. 2017 [33]	21	12	33.3	83.5		NA
Jahangir et al. 2019 [14]	51	13.9	0	84.3	98.1	21.5
Aljawadi et al. 2020 [15]	80	22	1.25	88.3	96.25	18.75
Current Study	102	25	0.98	86.73	97.05	19.6

debridement (as defined by > 12 h delay from time of injury) [26]. Similarly, a systemic review published by Schenker reported no association between late debridement and risk of developing superficial/deep infections [4]. In our series, only 47 of 102 patients (46.07%) had their first debridement after 12 h from injury.

The current guidelines form the BOA and BAPRAS recommended that all open fractures should have definitive wound closure within 72 h of injury [11]. The duration between injury and the definitive flap cover was considered to be critical in determining the risk of postoperative flap related complications, including infection and flap failure [27, 28]. However, only 24.50% of patients included in our study had their definitive surgery within 72 h of injury.

Superficial wound infection reported in 32 patients from our series and developed in a mean time of 5.8 months after the definitive procedure. We did not find any significant association between timing of first debridement, or timing of definitive surgery and superficial wound infection.

Our deep infection rate (0.98%) is lower compared to what is currently reported in literature. Gopal et al., Naique et al. and Mathew et al. had reported a deep wound infection rate between 8.5% and 14.9% following one-stage procedure for patients with Gustilo IIIB open fractures [1, 13, 29]. Table 6 compares our outcomes to currently available series.

Conclusion

Our results showed that low infection rate, high union rate, low reoperation rate, and excellent limb salvage rate can be consistently achieved in these complex injuries by following a combined Ortho-Plastic approach, MDT input and meticulous technique. Timing of first debridement, or timing of definitive surgery may not be associated with any significant increase in superficial or deep wound infection rate, non-union rate, or limb salvage. We believe that the focus should be on Getting It Right First Time (GiRFT), rather than timing of surgery.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Informed consent was obtained from all individual participants included in the study.

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