Management of severe lower limb injuries: a 4-year experience with a revisited recent approach at Zagazig University Hospital, Plastic Surgery Department

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Background
Management of complex open fractures of the lower extremities needs a special multidisciplinary team in major trauma centers. Limb salvage is attempted in appropriately selected patients via joint orthopedic and plastic surgery care. Recent guidance shows strong evidence of better long-term functional outcomes and decrease of complications when coordinated combined orthoplastic approach can be successfully delivered.
Patients and methods
A total of 52 patients were included in this retrospective comparative study of the outcomes from two approaches, managed either by single-team approach, plastic or orthopedic (group A), or by orthoplastic setting (group B), in Zagazig University Hospitals between August 2016 and July 2020. All data were collected from the patient records. Follow-up outcomes involved fracture union, weight bearing, persistent deep infection, and secondary amputations.
Results
The most encountered injury pattern in both groups was Gustilo IIIb. The majority of those injuries were sustained owing to road traffic accidents in both groups. The mean bone loss was 2.05±2.3 cm in group A and 2.06±2.2 cm in group B. There was a statistically significant difference between the mean time to initial debridement, where in group B, it was 8±2.04 h, whereas in group A, it was 10.7±4.2 h (P=0.05). The time to definitive fixation showed a highly significant difference from 9.8±2.9 weeks in group A to 4.4±0.8 weeks in group B. The relative risk for flap loss showed significant reduction in group B (P=0.021).
Conclusion
Overall outcomes showed obvious improvement with less complication rate of the combined orthoplastic approach over the previous single-team speciality. Nonetheless, certain complications like nonunion and need for secondary amputation did not show quite a significant difference, which may indicate that our early experience with orthoplastic approach for the management of open tibia fracture is in need for further audit and refinements to take place.

Keywords:
complications, guidelines, lower limb, open tibia fracture, orthoplastic, outcome

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Introduction

Management of complex open fractures of the lower extremities needs a special multidisciplinary team in major trauma centers [1,2]. Limb salvage is attempted as a standard of care in appropriately selected patients. Outcomes are affected by a complex interplay among patient, injury pattern, and surgical factors [3,4]. Complications like deep infection in patients who have undergone limb salvage can lead to significant adverse sequelae such as readmission to hospital, further surgery, and delayed amputation [5,6]. Despite the complex nature of these injuries, a single-specialty approach used to be the standard management for decades. Therefore, joint orthopedics and plastic surgery care has been refined and recognized as a standard of care for complex multitissue lesions in several hospital settings [7,8].

In 2009, standards for the management of open fractures of the lower limb in the UK were suggested by a joint collaboration combining orthopedic [British Orthopaedic Association (BOA)] and plastic surgery [British Association of Plastic and Reconstructive Surgery (BAPRAS)] expertise [9]. In the treatment of severe open tibial fractures, the orthoplastic approach in the UK was associated with a better clinical outcome than the exclusively orthopedic approach [10]. Despite some limitations, a coordinated combined approach to both the bony and the soft tissue components of open tibial

fractures can be successfully delivered to achieve better long-term outcomes and decrease the associated complications [5,7,11].

In Zagazig University Hospitals (ZUH), the standard practice for managing open tibia fractures was set for decades in a way that a separate speciality is involved in the primary management, mainly orthopedics. Rarely, further management might be arranged for joint care with plastic surgeons. Unsurprisingly, lack of effective communication has been adversely reflected on the overall outcome.

Following strong evidence-based guidelines [7,9], orthoplastic approach has been implemented in ZUH, in a multidisciplinary setting, relying broadly on the BAPRAS guidance, combining dedicated plastic surgeon with an interest in lower limb reconstruction and orthopedic trauma surgeons for the primary and definitive management for these injuries.

This study compares the results of both approaches, where the focus is placed on conducting the definitive orthopedic and plastic surgical procedures in a single stage after early debridement and skeletal stabilization.

Patients and methods

This retrospective comparative study has been conducted in ZUH between August 2016 and July 2020. All the patients were enrolled after obtaining the approval from the institutional review board ethical committee and consents have been signed from every patient. A total of 71 patients with open tibial fractures were presented to the emergency trauma department. Overall, 12 patients had primary amputation owing to either a nonsalvageable mangled or an associated life-threatening condition and seven patients were excluded owing to inconsistent follow-up. Ultimately, 52 patients were included in this study.

Between August 2016 and July 2017, 20 patients were admitted to an orthopedic trauma unit where primary treatment was initiated involving fasciotomies, debridement, and skeletal stabilizations (group A). Thereafter, a referral request to plastic surgery used to be the next step for soft tissue reconstruction. The patient journey ended with a final referral to orthopedics for definitive fixation.

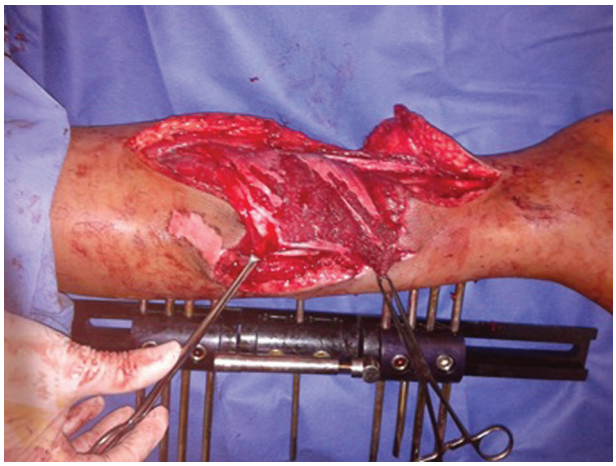
The application of orthoplastic approach practice started in August 2017, and then 32 patients were admitted and treated according to the following proposed orthoplastic approach (group B).

After exclusion of life-threatening conditions on primary and secondary surveys, according the guidelines of advanced trauma life support at the emergency department, a focused history was taken involving mechanism of injury and comorbidities. The local examination aimed to identify vascular and nerve injuries, compartment syndrome, and extent of soft tissue damage. Any hemorrhage was controlled, and then a temporary wound sealing and limb immobilization was applied, and then the patient was sent for radiographic assessment. Antibiotic and anti-tetanus serum prophylaxis were administered as soon as possible according to the recommended protocol.

The criteria for immediate surgical approach were gross contamination of the wound, compartment syndrome, vascular injury, or other associated injuries. In the absence of any of these criteria, patients were managed within 24 h in an elective trauma operating list, where thorough debridement of soft tissue and bone was completed. Gustilo-Anderson classification [12] was used to describe the injury severity. A spanning external fixator was used as the primary skeletal stabilization technique, and then a temporary wound dressing was applied; unfrequently, negative pressure wound therapy was used (Fig. 1).

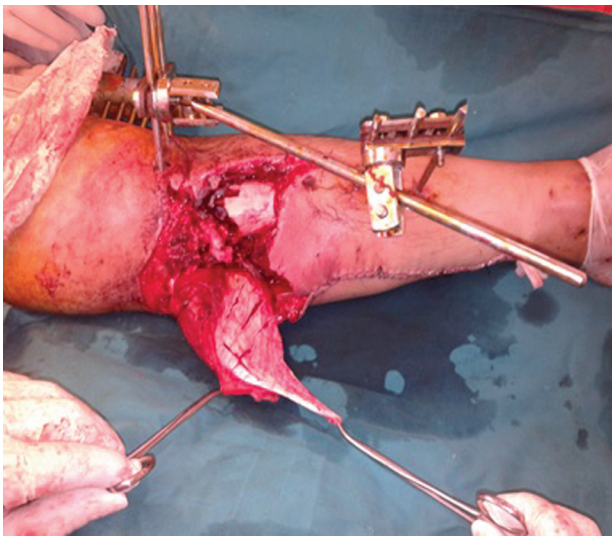
The definitive soft tissue coverage within 3–4 days was attempted in the form of local muscle and fasciocutaneous flaps, microvascular free flaps, or cross-leg flap. If necessary, a definitive skeletal stabilization by changing to internal fixation or the use of bone graft was completed after complete soft tissue healing. Examples are shown in Figs 2–6.

Figure 1



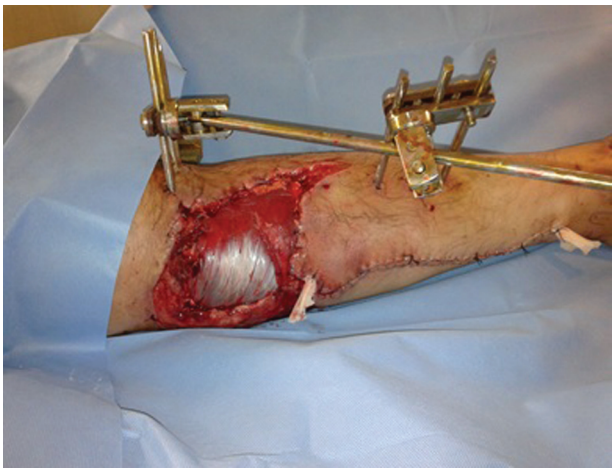
Open tibia fracture GA IIIb mid-leg underwent early debridement through extended fasciotomy incisions, external fixator, and reconstruction with hemisoleus flap. GA, Gustilo-Anderson.

Figure 2



An example of GA IIIb underwent orthoplastic debridement, spanning external fixation and reconstruction with medial head of gastrocnemius muscle. GA, Gustilo-Anderson.

Figure 3

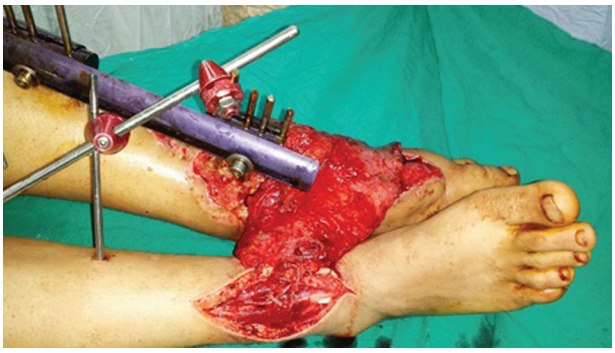


Definitive coverage was successfully achieved and external fixator *in situ*.

Figure 4

Reconstruction of lower third open tibia with free anterolateral thigh (ALT) flap.

Figure 5



Reconstruction of lower third open tibia GA IIIc and anterior ankle with cross latissimus dorsi (LD) free flap due to difficult access to recipient vessels in injured limb. GA, Gustilo-Anderson.

Data were collected from patient records, including demographic data, type of trauma, Gustilo-Anderson classification, operative data (primary debridement and skeletal stabilization), type of soft tissue coverage, and type and time for definitive skeletal stabilization. Long-term outcome data were collected from patient records or follow-up visits, including fracture union, weight bearing, persistent deep infection, and secondary amputations.

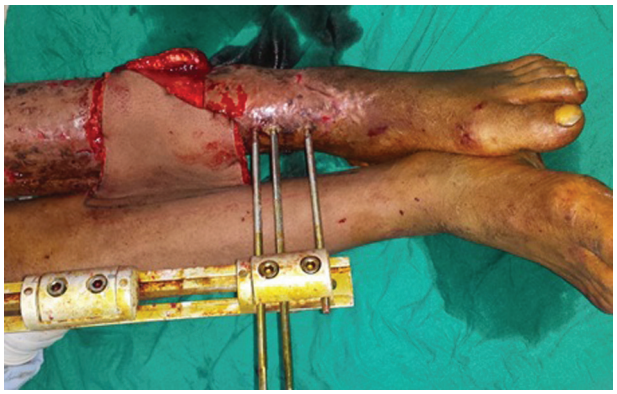
Assessment of chronic pain was done by visual analog scale, from 1 to 5. Enneking score expressed as a percentage of a patient's noninjured limb function was used as a subjective method for measuring the functional outcome. We included the original devised variables to assess walking distance, walking aids, gait, overall function, and psychological perception of outcome [13,14].

Data were analyzed using SPSS, v22 (IBM Corporation). We hypothesized that the type of intervention, that is, the orthopedic and orthoplastic procedures, may influence the outcomes, irrespective of surgeon. For the categorical variables, contingency tables were used, the frequency distribution was calculated, and the χ^2 test was used to highlight the differences between the two groups. For continuous variables, independent samples t test and Mann–Whitney test were used to compare the outcome between the two groups. Relative risk was used to highlight the development of infection and nonunion. The confidence interval was 95%.

Results

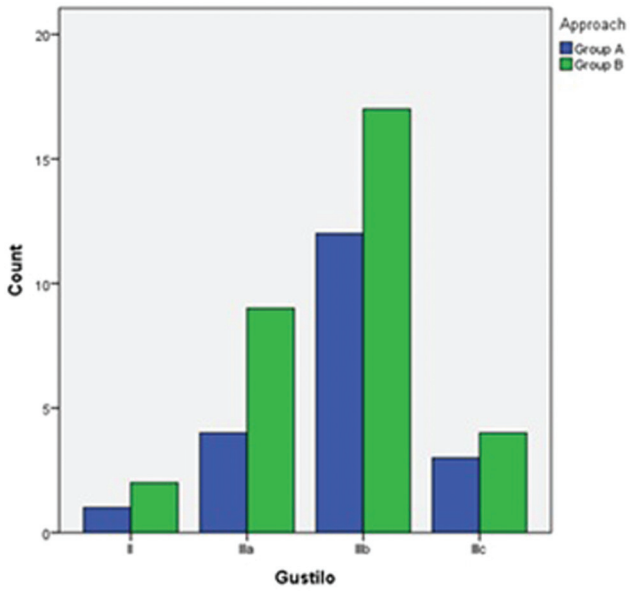
In total, 52 patients were included, where 20 patients were managed by single-speciality-team approach, and 32 patients were managed by the combined

Figure 6



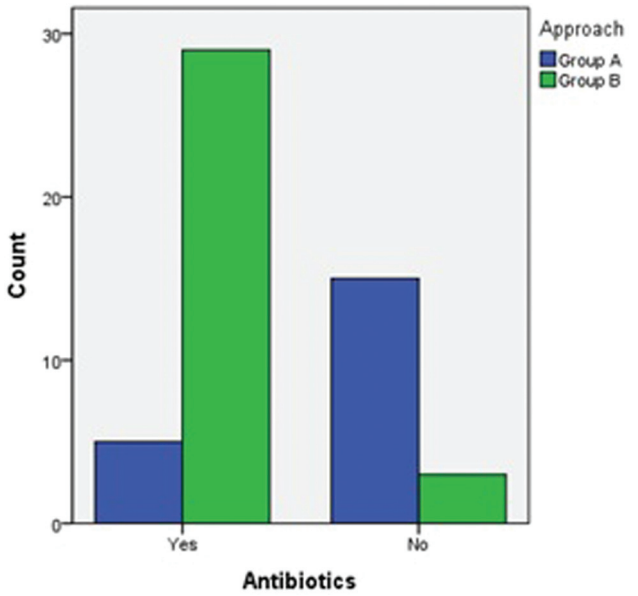
Salvaged failed free flap reconstruction of middle third open tibia fracture with cross-leg flap.

Figure 8



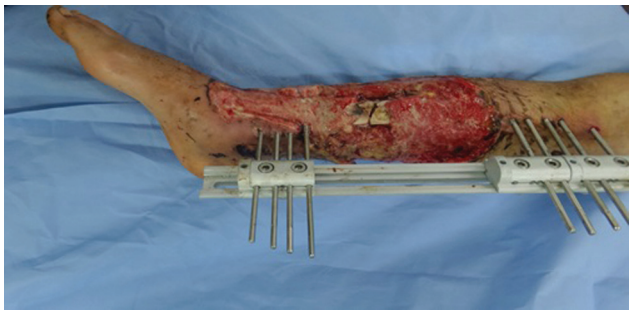
Fracture classification after initial debridement, showing the most common type in both groups was IIIb.

Figure 7



Change of practice toward administration of antibiotics after application of orthoplastic approach.

Figure 9



An example of delayed presentation with suboptimal bone and soft tissue debridement, managed in a single-speciality team (group A).

orthoplastic approach. Basic demographic figures were nearly similar in both groups, where male sex was predominant in both groups (85% for group A and 91% for group B), and the mean age was 30±11 years for group A and 31±10 years for group B.

In both groups, the main leading causes were either road traffic accidents or firearm injuries. The majority of those injuries were sustained due to road traffic accident (85% in group A and 93% in group B).

After initial assessment, 90% of cases have been given antibiotics and anti-tetanus prophylaxis in group B compared with only 25% of cases in group A (Fig. 7).

During the initial debridement, 12 cases required fasciotomy: five (25%) cases were in group A and seven (21%) cases were in group B. The mean bone loss after debridement was 2.05±2.3 cm in group A and 2.06 ±2.2 cm in group B. The most encountered injury pattern in both groups was Gustilo IIIb, as shown in Fig. 8.

There was a statistically significant difference regarding the mean time to initial debridement; in group B, it was 8±2.04 h, whereas in group A, it was 10.7±4.2 h (P=0.05) (Fig. 9).

Although the mean time to definitive coverage was 6.6 ±2.6 days in group A, this has been significantly reduced to 4.1±1 in group B. Therefore, time to definitive fixation showed a highly significant reduction from 9.8±2.9 weeks in group A to 4.4±0.8 weeks in group B (P=0.000).

Figure 10

Favorable outcome with normal gait and weight bearing of right lower limb, in a patient of group B, orthoplastic team approach.

Figure 11

Fully healed middle third fracture tibia with no evidence of deep infection, managed in an orthoplastic approach with acceptable mild angulation (radiograph).

For soft tissue reconstruction in group A, free flaps were used in 60% of cases, and equally local and regional flaps (20% for each) have been used in the remainder of cases. However, in group B, free and local flaps constituted 43.8% of cases for each, and regional flaps were the option only in 12.4% of cases (Figs 10 and 11).

The estimated relative risk ratio for developing complications showed lower risk in group B. Details of incidence of complication are described in Table 1.

Comparing the outcome data between the two groups, it has shown significant better outcomes in group B. After application of orthoplastic approach, the mean hospital stay has declined from 15±5 to 11±3 days (P=0.002). Chronic pain assessment by visual analog scale also showed statistically significant difference in favor of group B (P=0.007). Enneking score was significantly higher in group B (average is 70%) (P=0.006).

Table 1 The relative risk for developing complications between the two groups with significant improvement in rate of flap loss and persistent deep infection in orthoplastic approach

Approach	Flap loss	Nonunion	Persistent deep infection	Need for secondary amputation
Group A (20)	6	5	10	4
Group B (30)	2	3	4	2
Relative risk ratio (A/B)	4.8	2.6	4	3.2
P value	0.021	0.129	0.003	0.131

Discussion

There is increasing awareness of improved outcomes of management of complex open tibial fractures according to the orthoplastic guidelines by BAPRAS and BOA. A new era has emerged for limb salvage since these guidelines have provided the evidence for collaborative plastics and orthopedics specialties joint management [11,15]. Therefore, we have conducted this study to compare our unit's outcome as we considered orthoplastic approach for management of severe lower limb trauma versus our old practice, that is, single-speciality-team approach.

The liaison with the orthopedic surgeon from the very beginning has facilitated effective debridement and proper skeletal stabilization and reconstruction planning.

There is a noticeable improved outcome between both groups in terms of functional outcome, reduced chronic pain, hospital stay, deep infection rate, and need for secondary amputation. However, there was no obvious difference in nonunion rate. This could be attributed to unexplored factors related to the operating

theater environment owing to lack of laminar airflow facility and probably lack of effective wound temporizing measures, that is, negative pressure wound therapy.

Moreover, the results have shown significant changes in the complication rate between the two groups. This can be attributed to improved practice with implication of multidisciplinary approach, antibiotic administration, proper timing for initial debridement, and early soft tissue reconstruction.

Previously, there was inconsistent practice of antibiotic administration, with no clear cut-off or precise duration or spectrum guidance. This has been changed by following a protocol of early administration of broad-spectrum antibiotics as soon as possible within the first 3 h of injury. This was consistent with the overall available evidence [16–18].

In single-team approach, there was no consensus regarding when first debridement could take place or who will be performing it. This was individually planned according to the patient route of admission after initial assessment in the emergency department without clear protocol. There was a lack of early communication between plastic reconstructive surgeons and orthopedic trauma colleagues. This has been clearly reflected on poor reconstructive plans and has led to loss of opportunities for early definitive fixation.

Since the consideration of the orthoplastic approach, the principles of management have been revised. Therefore, initial soft tissue and bone debridement was set to be undertaken by a senior plastic surgeoin and an orthopedic trauma surgeon on a semielective trauma list within 12 h of injury. This rule did not include cases needed emergent surgery within 6 h, when there was a clear indication for that. This was in line with the current BAPRAS and BOA guidelines [9]. This is believed to be the most important phase in the management of those open fractures. This perhaps produced a wound and a fracture condition that hopefully could lead to the intended optimum outcome of robust soft tissue cover and fracture union with significant decrease in deep infection rate.

The results of this study have shown that delay in soft tissue reconstruction beyond a week time in group A correlates to higher rates of deep infection. This agrees with the finding from a multivariate analysis of open tibial fracture management in literature [19]. Alfred *et al*. [20] and Lo *et al*. [21] have found a higher deep infection rate when soft tissue reconstruction was delayed beyond 5–7 days.

Although there was no significant difference in nonunion and flap loss rates, the relative risk shows lower complications in favor of group B, through improvement in management strategy mainly by multidisciplinary team approach and proper planning. This could be explained by the proportional higher rate of reconstruction by local and regional flaps. In similar studies, early free flap failure rates of 11% for lower extremity trauma have reduced to 3.7% when such improvements have been implemented [20,21].

In this study, the average Enneking score after application of the orthoplastic approach was 70%, which is comparable to similar studies that found that the average Enneking score of functional outcomes of reconstructed limbs to the noninjured limbs for Gustilo IIIb open fractures was 75% [7,11,14].

The cultural and personal meanings of amputation in Egyptian community may give explanation to the nonsignificant difference in need for secondary amputation. Albeit, the relative risk for secondary amputation is in favor of group A. Although it could be a rough outcome predictor, it is still an absolute indicator of poor long-term outcome. Most studies have attributed this to poor initial debridement, reconstruction plan, poor limb function scoring, chronic pain, or owing to persistent deep infection [22].

Conclusion

The overall outcomes in this study showed obvious improvement with less complication rate of the combined orthoplastic approach over the outdated single team speciality approach. Nonetheless, certain complications like nonunion and need for secondary amputation did not show quite a significant difference, which may indicate that our early experience with orthoplastic approach for the management of open tibia fracture is in need for further audit and refinements to take place.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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