

Staged Protocol for the Treatment of the Severe Open Tibia Plateau Fractures

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Research article

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Abstract

Introduction Open tibia plateau fractures is one of the most challenging problems in fracture surgery and often results in high rates of complications. Staged protocol for treatment of these complex injuries is preferred and appears low rates of complications. The aims of this study is to analyse the results of staged protocol for treatment of severe open tibia plateau fractures.

Materials and Methods 11 patients with grade III (Gustilo) open tibial plateau fractures (Schatzker V and VI) were treated by staged protocol. The time from first stage operation to the definitive internal fixation, time of bone union and range of motion were investigated. And incision necrosis, surgical site infection, internal fixation related complications, and non-union were recorded. At the last follow-up visit, the independent knee assessments were carried out using the Rasmussen's clinical and radiologic scores.

Results The articular surfaces fragments reduction and limb alignment correction were satisfactorily obtained in all the patients during the first stage operation. The mean time from first stage operation to the definitive internal fixation was 24.7 days (19–34 days). All the patients achieve union at a mean of 5.2 months (range, 3–8 months). The average knee range of motion was 116.4° (100°–130°). No cases of these patients incurred deep infection. The Rasmussen's radiologic scores revealed the mean scores were 15.5 (range 12 to 18). And the mean Rasmussen clinical score was 26.1 (22–29).

Conclusions The staged management technique is a safe method associated with good clinical and radiological outcomes in severe open tibial plateau fractures. And we emphasizes the important of the articular surfaces fragments reduction and fixation and limb alignment correction during the first stage operation.

Introduction

Open tibial fractures account for about 25% of all the open fractures(1). It result in high rates of complications, such as, wound dehiscence, the soft tissues and bone infection, exposed bone and internal fixation, and nonunion(2, 3). The staged management of open tibial fractures is preferred to minimize the risk of infection and soft tissue complications(4).

The open tibia plateau fractures are relatively rare reported. Circular wire external fixation with/without limited internal fixation have been published on the treatment of severe tibia plateau fractures (including small cases of open tibia plateau fractures)(5–9). This technique provides closed reduction and the stabilization, and does not necessitate excessive soft-tissue dissection. However, it associated with high rate of pin track infection.

And it is reported that open tibial plateau fractures were successfully treated by antibiotics administered, irrigation and thorough debridement, immediate rigid internal fixation, and delayed primary closure at 5 days (10). Complex bicondylar tibial plateau fractures (including 11 cases of open tibia plateau fractures) were treated by dual plating using anterolateral and posteromedial incisions associated with low

incidence of soft tissues complications after proper soft tissue preparation (11). ORIF using anterolateral and posteromedial incisions allow direct bone fracture reduction and better biomechanical fixation. Moreover, minimally invasive stabilization techniques is an acceptable alternative for treatment of open tibial plateau fracture(12, 13).

Staged protocol for the treatment of high-energy proximal tibia fractures (41 closed and 16 open fractures, 95% of Schatzker V and VI) is preferred and appears low rates of complications(14). The aim of this study was examine the outcomes of 11 patients with grade III (Gustilo) open tibial plateau fractures (Schatzker V and VI) were treated by staged protocol. And we emphasizes the important of the articular surfaces fragments reduction and fixation and limb alignment correction during the first stage operation.

Patients And Methods

Between March 2015 and July 2019, 11 patients with grade III (Gustilo) open tibial plateau fractures (Schatzker V and VI) were treated by staged protocol (Fig. 1). The Staged protocol was defined as: first stage debridement, tibia plateau fractures reduction and Kirschner wire fixation, correction of limb alignment, and temporizing knee-spanning external fixation combined with vacuum sealing drainage, second stage repeated wound debridement and application of VSD, and followed by definitive internal fixation. Seven of the 11 patients were men and 4 of these patients were women. The average age was 45.55 ± 11.8 years old (range, 26–66). Radiological examination showed that 5 of these patients had Schatzker type V fractures and 6 were Schatzker type VI. Eight of the 11 patients were Gustilo grade IIIA tibial plateau fractures and 3 of these patients were Gustilo grade IIIB. 9 cases of open wounds mainly involved lateral tibia plateau and 2 cases of open wounds were mainly located in the medial tibia plateau. Each fracture was also classified according to the AO classification. Demographics and fracture characteristics were shown in Table 1.

Table 1
Demographics and fracture characteristics.

Case	Age	Sex	Gustilo type	Schatzker type	AO type	No. of VSD	Days from injury to definitive internal fixation
1	66	male	IIIA	VI	C3	2	23
2	36	female	IIIA	V	C2	3	25
3	42	male	IIIB	VI	C3	3	24
4	57	male	IIIA	VI	C2	2	22
5	26	male	IIIA	V	C2	2	24
6	56	female	IIIB	VI	C3	4	34
7	47	male	IIIA	V	C3	3	26
8	32	female	IIIA	V	C3	2	19
9	41	female	IIIA	VI	C3	2	20
10	52	male	IIIA	V	C2	4	29
11	46	male	IIIB	VI	C3	3	26

Inclusion criteria were age more than 17 years old, grade III (Gustilo) open tibial plateau fractures (Schatzker V and VI) underwent staged treatment, and followed up for at least 12 months. Exclusion criteria were closed tibial plateau fractures, single-stage internal fixation for the open tibial plateau fractures, definitive external fixation for the open tibial plateau fractures, or coexisting vascular or neurological lesions.

All patients were operated by the same team. Under either general or spinal anesthesia, all the patients underwent first stage operation within 6–8 hours after injury. Debridement of soft tissue and bone were performed after the wound irrigating with normal saline, hydrogen peroxide and dilute iodophor solution for three times. And then, tibia plateau fractures were reduced and fixed by Kirschner wire through the open wounds. To obtain an anatomical or proximate to anatomical reduction of tibia plateau fractures, the auxiliary incision was performed in the tibial plateau with intact skin if necessary. Temporizing knee-spanning external fixation is used for providing primary stability of tibia plateau fractures and correction of limb alignment. At last, application of vacuum sealing drainage (VSD) achieves the wounds closure. X-ray images and CT scans were obtained postoperatively (Fig. 2). Every patient received 3 g of cefazolin every 12 hours until the leukocyte count and the CRP (C-reactive protein) retain to the normal level. Until the wounds were closed and heal, second stage repeated wound debridement and application of VSD are required in all of these patients.

After the soft tissue condition was stable, all the patients underwent operation for definitive internal fixation by the same surgeon. Under either general or spinal anesthesia, the temporizing knee-spanning external fixation was removed. Internal fixations were performed by minimally invasive incision in 8 cases of the patients. Because of limb malalignment after temporizing knee-spanning external fixation, one standard lateral or medial skin incisions were performed for correction and internal fixations and another lateral or medial minimally invasive incision were used for internal fixations in 3 cases of patients. Autologous tricortical graft from the iliac crest was used in 2 cases of patients. After definitive internal fixation, manual release of the knee joint was routinely conducted and mobilization of the knee joint achieved 90–100° in all of these patients. And the physical examination of the knee stability was performed to exclude ligament injury. X-ray images and CT scans were obtained immediately postoperatively. Passive motion of joints was encouraged immediately after operation (Fig. 3). And active motion of joints began from the third day of operation after pain relief. Partial weight-bearing (to a maximum range of 30–40 kg) with crutches started at 8–12 week postoperative. Patients were permitted full weight-bearing when trabecula through fracture line and the fuzzy fracture line were observed on both the anteroposterior and lateral X-ray images.

All the 11 patients were clinically and radiologically followed up at every month until X-ray examination confirm union of the fractures. And then, clinically and radiologically were evaluated every 3 months at a minimum of 12-month. The time from first stage operation to the definitive internal fixation, time of bone union, range of motion, incision necrosis, surgical site infection, internal fixation related complications, and non-union were recorded. At the last follow-up visit, the independent knee assessments were carried out using the Rasmussen's clinical and radiologic scores.

Results

The average follow-up was 17.6 months (13–28 months). The articular surface reduction was evaluated by radiographic Rasmussen score after the first stage operation. 2, 7, 2 cases of patients obtained excellent, good, and fair articular surface reduction postoperative, respectively. And the X-ray images indicated the restoration of the gross limb alignment after the first stage operation. Before the wounds were closed and heal, second stage repeated wound debridement and application of VSD are required once in 5, second time in 4, and third time in 2 cases of these patients, respectively. The mean time from first stage operation to the definitive internal fixation was 24.7 days (19–34 days). All the patients achieve union at a mean of 5.2 months (range, 3–8 months). The average knee range of motion was 116.4° (100°–130°) (Fig. 4). No knee instability or pain was found in all cases. 2 cases of patients showed incision edge necrosis; this was cured by 4 to 8 weeks' course of dressing treatment. 1 cases of patient showed a superficial incision infection that could be completely controlled by appropriate antibiotics and dressing treatment. No cases of these patients incurred internal fixation related complications, deep infection, and non-union was reported. In addition, the Rasmussen's radiologic scores revealed the mean scores were 15.5 (range 12 to 18) at the last follow-up. The mean Rasmussen clinical score was 26.1 (22–29). All the patients were classified as satisfactory at last follow-up. Treatment and outcome of the definitive internal fixation were shown in Table 2.

Table 2
Treatment and outcome of the definitive internal fixation.

Case	Incisions of definitive internal fixation	Time to union (months)	Range of motion (degrees)	Complication	Rasmussen's clinical score	Rasmussen's radiologic scores
1	MIT	5	130	no	25	12
2	MIT	6	110	SII	26	16
3	MIT	4	120	no	28	16
4	MIT + SLI	5	120	no	26	14
5	MIT	6	110	no	22	14
6	MIT + SMI	8	100	IED	27	16
7	MIT	7	130	no	29	18
8	MIT	5	120	no	26	16
9	MIT	4	100	no	26	14
10	MIT + SMI	4	110	SII	24	18
11	MIT	3	130	no	28	16

MIT minimally invasive technique, SLI standard lateral incisions, SMI standard medial skin incisions, SII superficial incision infection, IED incision edge necrosis

Discussion

Severe tibia plateau fractures (Schatzker V and VI) associated with extensive soft tissue injury are difficult to manage. Open tibia plateau fractures are rare because it was often the result of blunt trauma. In case of severe open tibia plateau fractures, treatments were usually even more difficult and the complication rate remained high (15), regardless of the treatment regimen used. Circular wire external fixation with/without limited internal fixation was used for the treatment of severe tibial plateau fractures (including small cases of open tibial plateau fractures). These techniques were appropriate for treatment of this kind of comminuted fracture with severe soft tissue injury, with low rate of complications (9, 16–22). Moreover, these techniques provided acceptable clinical and radiological outcome for severe open/closed tibial plateau fractures (5, 6, 8). For severe tibia plateau fractures, it suggested wire external fixation appropriate for open fractures and ORIF should be performed only for closed fractures with marked displacement (23). Although the using of external fixations avoid soft tissue injury, 20% rate of pin tract infection is present (24).

The goals of surgical treatment of tibial plateau fractures include the soft tissues protection, articular surface reduction and the anatomic limb alignment restoration to allow early knee motion. For severe

tibia plateau fractures, optimal reduction of comminuted lateral and medial articular surfaces requires visualization through an open reduction. Circular wire external fixations with/without limited internal fixations were more difficulty to obtain accurate reduction of the articular surface than ORIF. In 1992, a study reported 14 cases of grade II or III (Gustilo) open tibial plateau fractures (Schatzker V and VI) were treated by immediate rigid internal fixation without severe complication, such as deep infection (10). And dual plating using anterolateral and posteromedial incisions were used for 11 open tibial plateau fractures after proper soft-tissue handling (1 Gustilo type II, 7 type III-A, 2 type III-B, and 1 type III-C, AO/OTA 41-C3). This technique associated with low incidence of soft tissues related complications (11). ORIF techniques provide good visualization of fractures sites, but they may result in a higher rate of soft tissue related complications. To produce much less damage to the soft tissues, the minimally invasive stabilization techniques were performed for 10 open tibial plateau fractures (8 Gustilo Type IIIA and 2 Type IIIB, AO/OTA 41-C) (12). And a multicenter study indicated minimally invasive stabilization techniques is an acceptable alternative for treatment of open proximal tibia or tibial plateau fractures (13).

Wing external fixations produced less damage to the soft tissues but allowed little facility for reduction. ORIF provided optimal reduction of comminuted articular surfaces under visualization but associated higher rate of soft-tissue complications. In our study, we presented 11 cases of patients associated the comminuted articular surfaces fragments may be not permit adequate reduction and fixation by wing external fixations. And, the severe open soft-tissue injury with varying degrees of contamination affect primary internal fixation. The 11 patients with grade III (Gustilo) severe open tibial plateau fractures (Schatzker V and VI) were managed by staged protocol. Staged protocol involving temporizing knee-spanning external fixation and delayed definitive fixation had been reported for treatment of 57 cases of high-energy proximal tibia fractures (41 closed and 16 open fractures, 95% of Schatzker V and VI) (14). In this study, the articular surfaces fragments reduction and limb alignment correction were not mentioned during the first stage operation. We thought that it is very important for definitive internal fixation.

In our present study, during the first stage operation, the 11 cases of patients underwent radical debridement; the comminuted articular surfaces fragments were reduced and fixed by Kirschner wire through the open wounds and the auxiliary incision if necessary; and temporizing knee-spanning external fixation is used for providing primary stability of tibia plateau fractures and limb alignment correction. We fell that the first stage articular surfaces fragments reduction and fixation and limb alignment correction are very important for successful definitive internal fixation and satisfactory clinical and radiological outcomes. For grade III (Gustilo) open tibial plateau fractures, 3–4 weeks are often required for adequate healing of the soft tissues injury. If the articular surfaces fragments reduction and anatomic limb alignment are not satisfactory achieved it will be a disaster for the definitive internal fixation. In our series, the mean time from first stage operation to the definitive internal fixation was 26 days. We obtained satisfactory articular surfaces fragments reduction and anatomic limb alignment at first stage operation. During the second stage, minimally invasive incision was used for definitive internal fixation in 8 cases of the patients. Only 3 cases of patients required one standard lateral or medial skin incisions for limb alignment correction since limb malalignment was happened after temporizing knee-spanning external

fixation. After the definitive internal fixation, varying degrees of knee joint stiffness was noted in all of the 11 cases of patients. The mobilization of the knee joint achieved 90–100° by manual release. And the knee stability was confirmed by the physical examination. In our study, low rate of soft tissues complications were presented because of limited soft tissues detachment during the second stage operation. And these techniques achieved satisfactory clinical and radiological outcomes.

Our study emphasizes the articular surfaces fragments reduction and limb alignment correction is very important during the first stage operation. And then, limited soft tissues detachment for the definitive internal fixation can be applied in the second stage operation. There were several limitations in our study. The limited size of the study sample was insufficient for clinical evaluation. Moreover, this was a retrospective study and not randomized.

Conclusions

The staged management technique is a safe method associated with low rate of complications in severe open tibial plateau fractures (Gustilo Type III, Schatzker V and VI). And good clinical and radiological outcomes are possible when the articular surfaces fragments reduction and limb alignment correction were satisfactory performed during the first stage operation.

Declarations

Conflict of Interest:

The authors declare that they have no conflict of interest.

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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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Figures

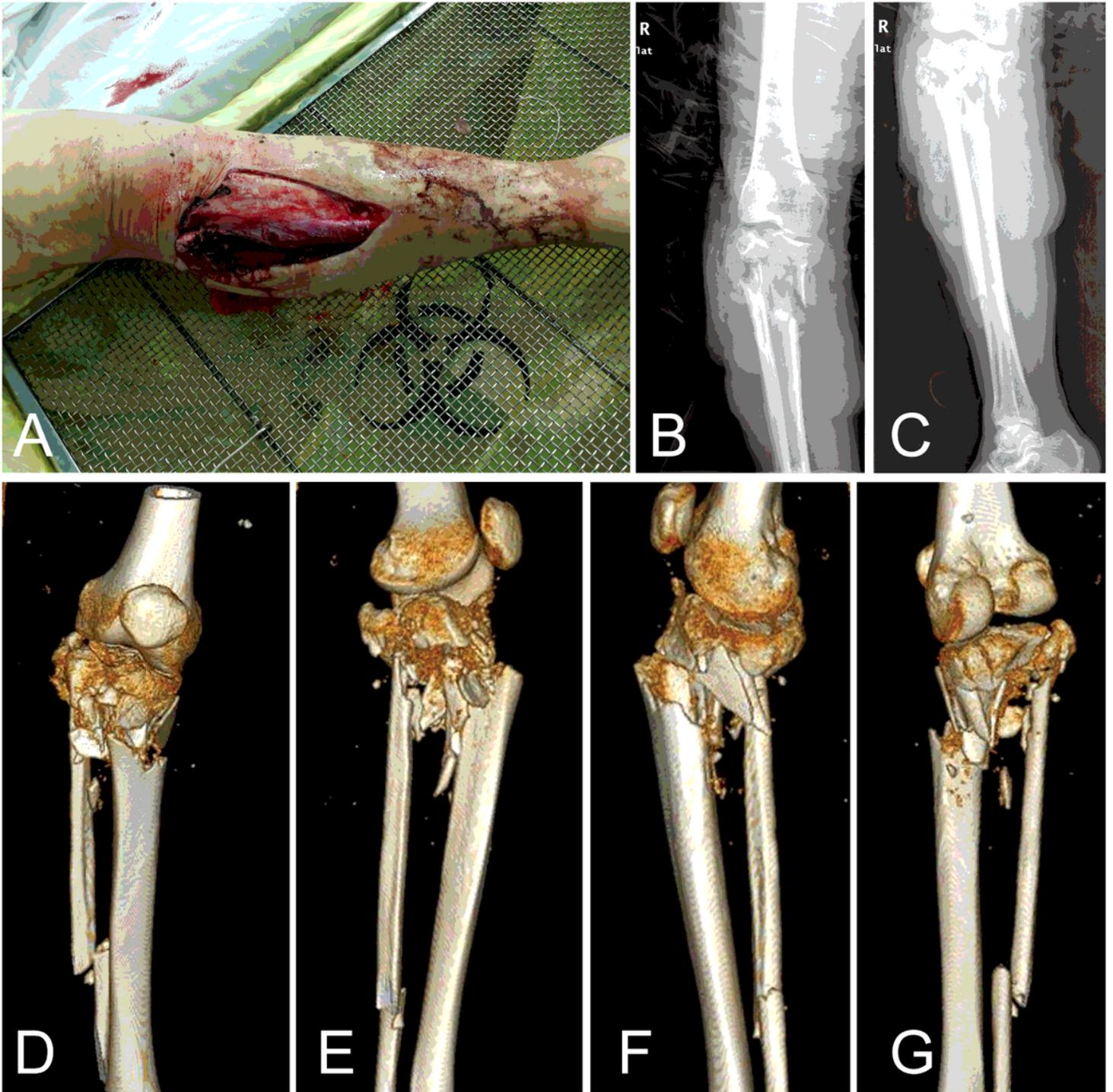


Figure 1

A 56-year-old female patient had grade IIIB (Gustilo) open tibial plateau fractures (Schatzker VI, AO C3). A, clinical photo showing grade IIIB (Gustilo) open tibial plateau fractures. B, preoperative anteroposterior and (C) lateral radiographs. D-G, preoperative three-dimensional CT scan.

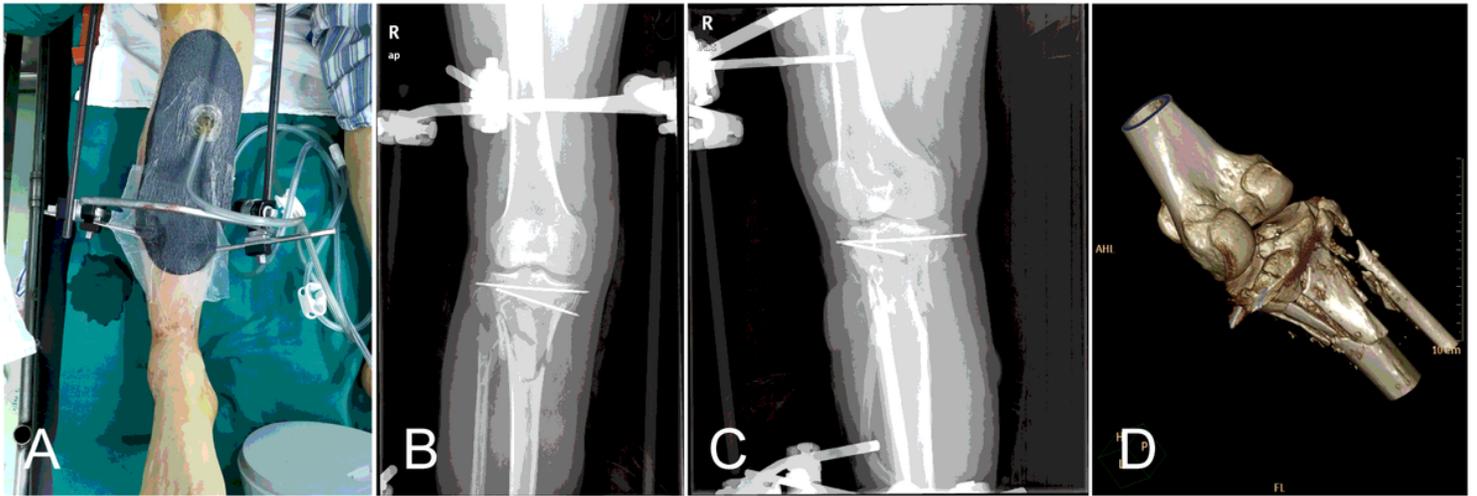


Figure 2

The patient underwent first stage operation, including debridement, tibia plateau fractures fragment reduction and Kirschner wire fixation, limb alignment correction, temporizing knee-spanning external fixation and application of VSD. A, clinical photo showing the wound closure by VSD. B, the first stage postoperative anteroposterior and (C) lateral radiographs. D, the first stage postoperative three-dimensional CT scan.

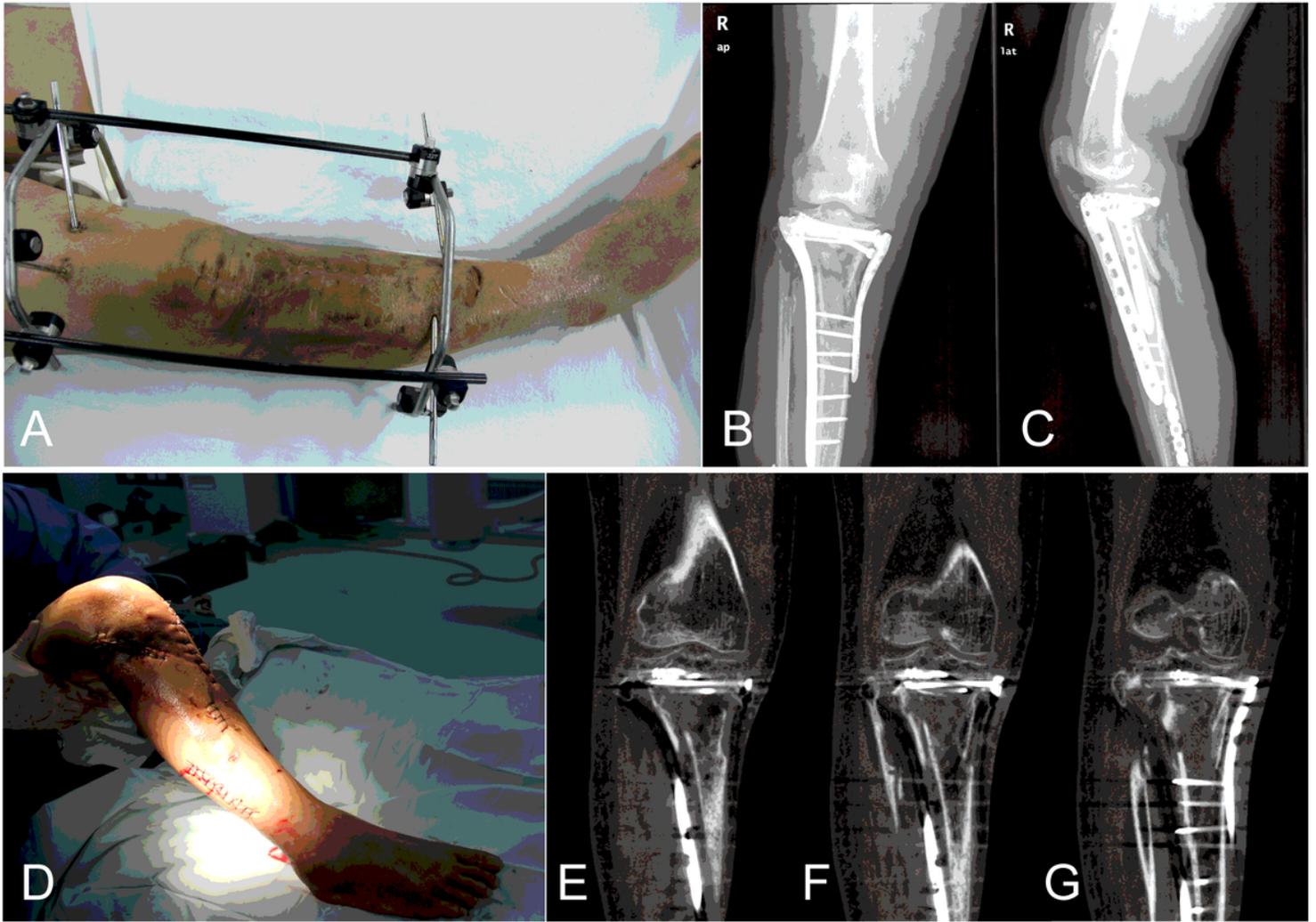


Figure 3

The lateral minimally invasive incision and standard medial skin incisions were used for definitive internal fixation 34 days after the first stage operation. A, clinical photo showing heal of the wound. B, the second stage postoperative anteroposterior and (C) lateral radiographs. D, after definitive internal fixation, manual release of the knee joint was conducted and mobilization of the knee joint achieved 90°. E-G, the second stage postoperative two-dimensional coronal CT scan.



Figure 4

Good clinical and radiological outcomes were obtained at 2years follow up. A, anteroposterior and (B) lateral radiographs showing bone union. C-E, the mobilization of the knee joint achieved 100°.