



STAGED TREATMENT OF HIGH ENERGY LOWER LIMB FRACTURES

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ABSTRACT

High energy lower limb trauma presents wide spectrum of challenges. The principles of damage control surgery have inspired the so called staged approach towards these difficult injuries. We present our experience with this new treatment modality and try to analyse its indications and limitations.

The span of the study reached 11 years. We operated 33 fractures of 32 patients (4 distal femoral fractures, 18 proximal and 11 distal tibial fractures). The average age was 45,7 years (26-71). All of the fractures resulted from high energy trauma.

The staged approach was implemented on lower limb fractures complicated with soft tissue damage. The index surgery typically consisted of the application of a bridging external fixator. The second step was either a formal open reduction and plating, or a less invasive fixation with cannulated screws and a hybrid ex. fix.

All 33 fractures united for a mean period of 16 weeks (12-30 weeks).

Fifteen patients had excellent, 11 had good, 5 had average and two had poor ratings. There were no serious intraoperative complications, deep infections, septic arthritis or osteomyelitis. Skin necrosis developed in 3 cases. There were four cases of delayed healing. Pin track infection occurred in 10 patients. Late articular collapse was noted in 2 cases. Three knees had medio-lateral instability.

Staged approach offers favourable balance between safety and functional recovery. The decision about the type of definitive fixation depends on the morphology and localization of the fracture, as well as on the experience and equipment of the treating surgical team.

Keywords: high energy, tibial fracture, distal femoral fractures, staged treatment,

High energy trauma presents a wide spectrum of challenges. The effects on the whole body and not only the skeletal system seem to determine the outcome. Initial inflammatory reaction is triggered by the tissue damage. Historically the treatment recommendations have ranged dramatically from totally conservative [1] to aggressively

surgical [2]. The poor functional results being result of disrupted anatomy in the first case and disrupted biology in the second. In an attempt to find balance between the two approaches a staged protocol relies on the principles of the so called "damage control" [3, 4.]

. The prompt, atraumatic stabilization of the extremity, fastens the transition of the posttraumatic inflammatory reaction. The definitive fixation is then performed as a second stage procedure, when the soft tissue condition has improved [5]. We present our experience with the staged treatment of the high energy lower limb fractures and try to analyze the indications and the limitations of the method.

METHOD

The staged approach was implemented on lower limb fractures complicated with soft tissue damage. The index surgery was performed immediately after admission and typically consisted of the application of a bridging external fixator (ex. fix.) that exerted moderate traction on the fracture site. Every attempt was made to restore the axial and rotational alignment of the limb without articular reduction. The placement of the Schanz screws was planned out of the path of the future plate. Open fractures were debrided and antibiotics and antithrombotic prophylaxis was started. CAT scan was then performed to help planning of the next stage of the treatment. The limb was elevated. The definitive surgery was performed after the inflammatory stage subsided. Typically after 9-10 days.

The second surgery was either a formal open reduction and plating or a less invasive fixation with cannulated screws and a hybrid ex. fix. The latter was implemented for the definitive stabilization of all open fractures grade 3 according to Gustillio/Anderson classification [6] and the fractures with excessive soft tissue damage. The rest of the fractures were stabilized with buttress plates (both locked and conventional), after a formal open reduction. At this point bone grating was also performed whenever deemed necessary. Passive range of movement (ROM) was started immediately after the pain subsided. Touch weight bearing was allowed by the end of the second month. Full weight bearing was postponed until Ro evidence of fracture healing, which typically occurred after 3 months.

MATERIAL

The span of the study reached 11 years (May 2006 –February 2017). We included 33 fractures of 32 patients (4 distal femoral fractures, 18 proximal and 11 distal tibial fractures). 25 of the patients were men, the rest 7 women. The average age was 45,7 years (26-71).

All of the fractures resulted from high energy trauma- 15 falls from height and 16 road accidents, one agricultural accident.

The AO classification was used to describe fracture morphology [7] Fracture types are presented in table 1.

Table 1. Fracture type

AO/ASIF type	A2	A3	C1	C2	C3
N	8	5	0	3	17
total	13		20		

The condition of the soft tissues was rated according to the criteria of Tscherne/Oestern [8] and Gustilio/Anderson [6]. There were seventeen open fractures –types II 7 cases, types IIIA-8 cases and types IIIB –2 cases. The

limbs with soft tissue damage were fifteen. According to the classification of Tscherne/Oestern, 3 had lesion type C1, 6 lesion type C2 and the rest type C3 (table 2).

Table 2. Type of soft tissue lesion

Type	Open fractures Gustilo and Anderson			Closed fractures Tscherne and Lobenhoffer			
	II	IIIA	IIIB	C0	C1	C2	C3
N	7	8	2	0	3	6	5
Total	17			15			

RESULTS

All 33 fractures united for a mean period of 16 weeks (12-30 weeks).

Clinical assessment was done according to the criteria of the Knee Society Clinical Rating Score [9] for the distal femoral and proximal tibial fractures (GROUP 1 N=21).

Two hundred points are awarded in 2 categories: objective assessment (pain, stability, ROM) and functional rating (walking, climbing stairs)

A well aligned, stable and painless knee joint with a ROM of at least 125° receives 100 points. The maximal functional rating is again 100 points and describes a patient who can walk unlimited distances and climb and descent from stairs in a normal fashion.

The results from the distal tibial fractures (GROUP 2 N=11) were rated, according to the criteria of the AOFAS (American society for surgery of the foot and ankle) [10]. In this system 100 points are distributed in two categories:-objective rating (pain, stability and ROM) and functional rating (walking on uneven surfaces and stair climbing).

Both rating systems are widely used in similar studies [11, 12, 13]

In Group1 11 patients had excellent, 6 had good, 2 had average and two had poor ratings. The average objective rating was 85,5 (70-97), and the average functional rating was- 72,4 (40-100). The average ROM was 109° (100°-120°).

On the final follow up 14 patients were painless, 2

had slight and the rest had sporadic pain. Five patients could walk less than a kilometer and one needed a cane.

In Group 2, four patients received excellent, 5 received good and two satisfactory ratings. The average score was 78, 6 (63-97). The medium range of motion was 31° (15°-50°).

During the final examination, five patients had little pain while the rest had no pain at all. In six cases the walking was limited to less than a kilometer and two patients needed walking aids.

COMPLICATIONS

In spite of the larger number of open fractures, in our series, there were no serious intraoperative complications, deep infections, septic arthritis or osteomyelitis.

Skin necrosis developed in 3 cases. One case of IIIB open fracture, two proximal tibia fractures. They were debrided and healed under second intention.

There were four cases of delayed healing. All were fractures in the meta-diaphyseal area of the tibia. Two of the fractures was treated by a late bone grafting on the fifth month and healed uneventfully on the 30-th week. The other two fractures healed without operative intervention.

Two of the fractures in group 1 healed in 5° and 8° valgus respectively. Axial deviation of 7° varus was present in one case in group 2. No corrective surgery was performed.

The most common complication was pin track infection. It occurred in 10 patients. All of the infections

were superficial and we successfully treated with antibiotics and frequent pin track care. No ex. fix was discontinued

In six cases (group 2) a variable grade edema was present for more than 6 months, without signs of deep venous thrombosis.

One knee joint ended up with 20° flexion deficit.

Late articular collapse was noted in 2 cases. Both were treated percutaneously and hence no bone grafting was performed

Three knees had medio-lateral instability, with no functional impairment. No extra knee surgeries were deemed necessary.

DISCUSSION

Unlike the simple twisting and falling injuries, the high energy trauma presents a much bigger challenge. Living bone has visco-elastic properties. This means that it cannot withstand high velocity impacts. The energy released during the trauma is damaging tissues and the microcirculation. The exposed vessel endothelium initiates self-perpetuating pathophysiological processes. The vasoactive substances like calcitriol, prostaglandins and histamine increase the capillary permeability with consequent edema, hypoxia and acidosis [14]. This initiates the inflammatory phase of the trauma reaction. Modern understanding of these processes calls for urgent stabilization of the fracture in order to shorten that potentially detrimental phase.

The idea for less invasive treatment by an external fixator is a direct consequence of the visionary work of Max Scheck, who suggested limited osteosynthesis and joint distraction in the year of 1965 [15]. Sirkin uses the external fixator in the initial stage of treatment until the edema of the soft tissue had subsided. Definitive fixation is carried out in the second stage after an average period of 13 days. Thirty four patients have closed and 22 open fractures. In spite of the staged approach 17% of the limbs with closed fractures and 10,5% with open fractures develop skin necrosis. The percentage of deep infections in the first group is 3,5% while in second reaches 10,5%. One case ends up with an amputation [16]. Dickson treats in a staged fashion 37 fractures of distal tibia. The author performs late mini-invasive stabilization of the tibia after limited open reposition. The external fixator is kept till the fracture has united. Most of the fractures heal unevent-

fully (65%), but there still 8% of deep infections and 28% of the ankles have arthritic changes. Arthrodesis is performed in 11% and one case ends up with an amputation [1].

In a recent study Giordano presents the results of the treatment of thirty patients with unstable high-energy closed bicondylar tibial plateau fractures. Treatment involved a two-stage procedure. Two (6.7%) patients had superficial infection, one (3.3%) patient developed deep infection with loss of fixation. The overall reoperation rate was 10%. [17].

Ryu presents the results of 24 tibial plateau fractures treated in a staged fashion. Authors try to compare the clinical with the radiological results. The only clinically important parameter appeared to be the varus /valgus deviation [18]

It becomes clear, that in spite of its' lessened invasiveness the staged approach is not without problems.

There is some risk of bone contamination along the ex fix pins [19]. Their placement should be as far from the planned plate position as possible. Pin track care should also be strict and frequent.

If longer waiting is necessary in higher energy trauma, the fracture hematoma organizes and then proliferation causes fibrosis [20]. This process can make the reduction difficult and may necessitate extensive approaches and degloving, that could hinder bone healing. Because of that, proper initial axial and rotational alignment is very beneficial. In the event of an open fracture we used the initial wound (typically meta diaphyseal) to aid the reduction and the "joy stick" technique to elevate the articular fragments.

In our series there were no deep infections, although we had 51% open fractures. The reason for this favorable result may be connected with our treatment protocol.

Direct comparison of our results with those published in the world literature is difficult, because of differences in fracture pathology, the criteria for evaluation and the number of case. On the basis of our limited experience we can conclude, that the staged approach offers favorable balance between safety and functional recovery. The decision about the type of definitive fixation depends on the morphology and localization of the fracture, as well as on the experience and equipment of the treating surgical team.

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