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Temporary bridging trans-hip external fixation in damage control orthopaedics treatment after severe combat trauma: A clinical case series

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ABSTRACT

The role of external fixation in Damage Control Orthopaedics has been well described. Temporary external fixation has been recommended to provide relative bone stability while the soft tissue heals, prior to formal open reduction and internal fixation. Temporary bridging external fixation, that spans the joint, is recommended as primary skeletal stabilization in complex intra-articular and peri-articular fractures, in extensive peri-articular soft-tissue damage around the knee, ankle, elbow and wrist joints. Works devoted to temporary trans-hip external fixation in treatment of complex high-energy injuries are relatively rare.

The purpose of this article is to present our experience in using temporary hip spanning external fixation during primary treatment of six patients suffered from complex open intra-articular and peri-articular fractures of the proximal femoral bone with extensive soft tissue damage due to war blast or high-velocity gunshot trauma. Primary management was based on the concept of Advanced Trauma Life Support and Damage Control Orthopaedics. Conversion to definitive bone reconstruction was performed on the next stage of the treatment after general and local stabilization.

Introduction

Treatment of patients, who suffer from high-energy armed conflict injuries to the extremities, is challenging. The use of temporary primary external fixation is an attractive strategy in the staged treatment of complex fractures. Temporary external fixation provides possibility to prepare the patient and injured extremity for surgery, as well as plan the safe definitive surgery and personalized trauma care [1]. This method allows time for stabilization of the soft tissue envelope and also for thorough preoperative planning of the final surgical reconstruction based on computed tomography imaging and other needed diagnostic procedures. Unilateral external tubular fixation frames are mostly used, performing minimal invasive primary stabilization in a relative short surgery time.

Temporary trans-articular bridging is recommended for patients, suffering from complex peri-articular and intra-articular fractures, dislocations, extensive intra-articular penetrating injuries, massive damage to ligaments and articular capsule. This method has been successfully used for a long time to stabilize severely injured knee, ankle, elbow and wrist joints [2,3,4]. There are few publications in the available medical literature about the use of the spanning hip external fixation and its technical details in dealing with complex high-energy war trauma [5,6]. In this regard, we present our experience in treatment of six severely injured patients suffered from complex open intra-articular and peri-articular fractures of the proximal femoral bone with extensive soft tissue damage after blast and high-velocity gunshot wounds using temporary trans-hip bridging external fixation during Damage Control Orthopaedics (DCO) treatment.

Patients and methods

In this retrospective case series patients, who suffered from combat injuries to proximal femur and treated in our institution using temporary bridging trans-hip external fixation between 2013 and 2017, were included.

Upon admission to the hospital, life-threatening injuries were treated according Advanced Trauma Life Support recommendation's, fluid and blood products resuscitation was performed based

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on Damage Control principles. All patients received tetanus vaccination and antibiotic treatment according to the hospital protocol. Computed tomography-angiography procedure, performed routinely during the initial examination of the polytrauma victims, allowed not only to sufficiently visualize the location and extent of the bone fracture, but also to exclude or confirm concomitant vascular damage. There were no major arterial injuries in these group of patients. All patients had DCO application in the day of admission– debridement of the wounds and temporary bridging trans-hip external fixation .

Surgical technique

During primary operation under general anesthesia radical tissue debridement and massive washing of the wounds with ten liters saline solution was performed under general anesthesia. After debridement procedure all surgical instruments, drapes, gloves were discarded and injured extremity was re-draped before insertion fixation elements to the bones.

Temporary bridging trans-hip external fixation was performed as minimal invasive surgical stabilizing procedure in complex DCO. Positioning of external fixation frame across injured joints – temporary trans-articular bridging – required correct understanding of the complex anatomy of the injured limb and pelvis. Before half-pin insertion major blood vessels, nerves, muscle compartments, large bone fragments and skeletal landmarks were marked on the skin. A variety of modern modular external fixator systems facilitated easy and rapid application in almost any localization and configuration of the fracture.

When performing trans-hip bridging, stable proximal fixation to pelvis was usually achieved when a pair of 6-mm Schanz screws were inserted into the supra-acetabular zone or pair of 5-mm Schanz screws into the iliac crest. When performing iliac crest fixation, first long-treaded 5-mm Schanz screw was placed 1-2 cm posteriorly to the anterior superior iliac spine and the second one – at the level of the iliac tubercle. Both Schanz screws were directed towards the sacroiliac joint, avoiding perforation neither the inner nor the outer pelvic cortex. Schanz screws to the femoral bone (distal part of trans-hip external fixation system) were generally inserted from a lateral direction trough the external vastus of the quadriceps muscle with the knee flexed. We preferred 6 mm half-pins due to greater bending stiffness, which is almost twice than in 5 mm pins, and accordingly greater stability of the fracture fixation. If 5 mm pins are used, the number of them was increased. Three distal and three proximal half-pins in each of the main bone fragments were preferred.

Thin wire, used as probe, could help to determine the position of displaced bone fragments and in finding the right sites for screw insertion. Approximately one centimeter longitudinal skin incision and preparation of the channel to the bone bluntly was done, using straight clamp. A trocar and a drill sleeve were used for bone drilling and introduction of the half-pin, to protect the soft tissues from thermal injury and tissue twisting around the spinning instruments. The trocar was centered on the bone before drilling. Pre-drilling of both bone cortex was done, because self-drilling half-pins can be dangerous for anatomical structures beyond the cortex. Insertion of proximal half-pins into femoral bone close to the fracture zone were performed at a distance of 4-5 cm from the end of the bone fragment. The distal half-pins were introduced in to the bone near to distal femoral metaphysis. The wide base of the fixation increased its stability. Half-pins were inserted in both cortices of the femoral bone, with a point of the pin protruding trough the opposite cortex. Final check position of the pins was done using intraoperative radiograph. The outer ends of the pins were connected between each other in pairs from both sites of the fracture using two longitudinal tubes. Then both proximal (pelvic) and distal (femoral) half-pins groups were fixed to each other creating primary spanning external fixation device. It was desirable to use systems with larger diameter connecting rods. Manual distal limb traction reduced severe fracture displacement and improved position of the bone fragments in the state of realignment. Proper rotational alignment of the bone fragments was secured before final tightening the clamps. Any skin tension around the pins was released by extending skin incisions. It was possible to perform

Table 1
Demographics, injury characteristics, treatments and primary outcomes of six patients: PFN=proximal femoral nail; NPWT= negative pressure wound therapy.

Nr.	Age (years)	Injury characteristics	Primary external fixation	Type of conversation	Time of conversation	Soft tissue management
1.	22	Gunshot open left proximal femoral fracture Gustilo-Anderson IIIA. Admitted to hospital ten hours after injury.	Hybrid: 2 iliac crest half-pins and additional thin wire; 3 femoral half-pins.	Long PFN	5	Delayed sutures
2.	27	Multiple abdominal, pelvic and lower limbs shrapnel injuries with extensive soft tissue loss due to blast injury by anti-tank missile. Open right proximal femoral fracture Gustilo-Anderson IIIB. Critical general condition.	Unilateral: 2 supra-acetabular half-pins; 3 femoral half-pins.	Patient died in ten days due to the septic schock	-	-
3.	25	Multiple blast injuries in anterior right hip area and buttock. Open right proximal femoral fracture Gustilo-Anderson IIIA.	Unilateral: 2 iliac crest half-pins; 3 femoral half-pins.	Long PFN with cerclage wire	7	NPWT followed by skin grafting
4.	30	Gunshot open left proximal femoral fracture Gustilo-Anderson IIIA.	Unilateral:2 supra-acetabular half-pins; 3 femoral half -ins.	Long PFN	7	NPWT followed by skin grafting
5.	38	Open right proximal femoral fracture Gustilo-Anderson IIIB due to blast injury.	Unilateral: 2 iliac crest half-pins; 2 proximal femoral and 3 distal femoral half-pins.	Unilateral femoral external fixation	6	NPWT followed by skin grafting
6.	32	Open left proximal femoral fracture Gustilo-Anderson IIIB due to blast injury.	Unilateral: 2 iliac crest half-pins; 3 femoral half-pins.	Long PFN with cerclage wire	6	NPWT followed by skin grafting

temporary trans-hip bridging external fixation using different constructs: tubular unilateral or hybrid external fixation frames (proximal ⅓-ring with supra-acetabular or/and iliac crest half-pins with additional thin wire thorough iliac crest in combination with standart distal unilateral femoral fixation) [7,8]. These procedures were attempted by the minimally invasive technique without additional blood loss and in a relatively short time –in most cases up to one hour.

The pins were placed, where possible, outside the zones of soft tissue injury or away of the place in future planned definitive surgery [9], this usually determined our decision making of lilac crest versus supra-acetabular pins.

Local wound treatment was continued using method of negative pressure wound therapy (NPWT), followed by skin grafting or delayed sutures. Conversion temporary external stabilization to the internal fixation using long proximal intramedullary nails was performed in four of patients after general stabilization (usuall, 6–7 days after trauma).

Results

Six male patients suffered from blast and high-velocity gunshot proximal femoral open fractures were treated in our institution (Table 1). Mean age of these patients was 29.0 ± 5.6 years. Two patients presented high velocity gunshot injuries and four patients – blast injuries.

In all six patients temporary bridging trans-hip external fixation was performed as emergency surgical procedure in complex of DCO primary treatment.

In five of them, in a complex of other treatment measures, this allowed general stabilization of patients as well as the local condition of soft tissues in hip area and created appropriative conditions for subsequent reconstructive surgical internal and external fixation.

One patient, suffered from multiple abdominal, pelvic and lower limbs shrapnel injuries with extensive soft tissue loss due to blast injury by anti-tank missile and open right proximal femoral fracture Gustilo-Anderson IIIB and this patient died after ten days from septic schock.

Representative case of a 30 year old patient temporary trans-hip bridging and primary result after conversation of trans-hip external fixation to the long femoral nail after seven days is shown in Fig. 1.

Examplary case of management of one of the patients with questionable soft tissue coverage above proximal thigh is presented in Fig. 2. Femoral fracture fixation of this patient after trans-articular hip bridging was continued using tubular external fixation frame augmented by insertion of additional half-pins to proximal and distal femoral bone fragments through undamaged skin. Soft tissue management of this patient was continued by additional debridement procedures, NPVT followed by skin grafting.

Fig. 1. Case of a 30 year old patient, presenting blast injury to left proximal thigh. Radiograph on admission demonstrates comminuted left proximal femoral fracture with displacement (a). Temporary trans-hip bridging using unilateral external fixation frame – proximally iliac crest half-pins and distally femoral fixation (b,c). Seven days later conversion to long proximal femoral nail (d,e).

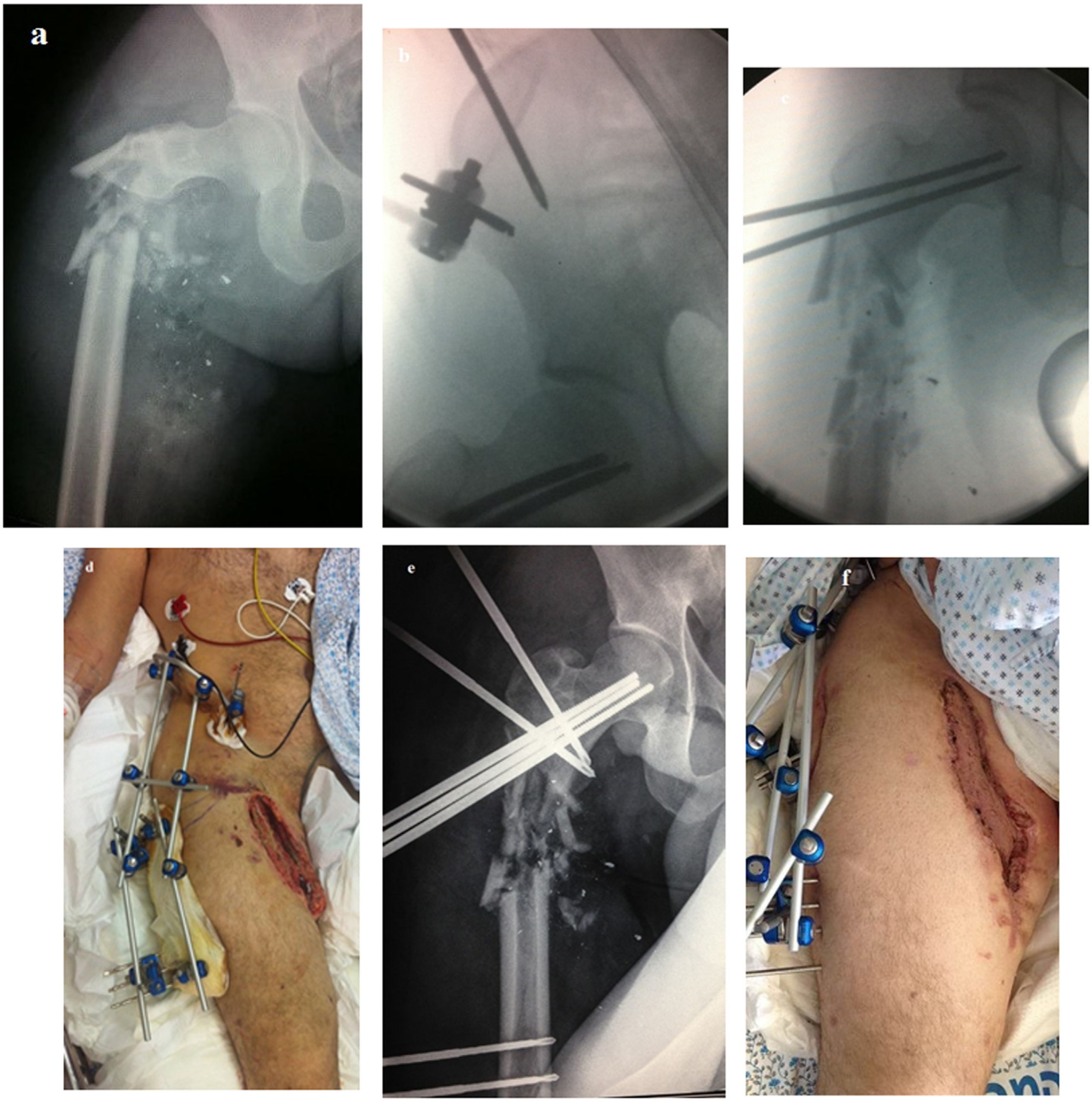

Fig. 2. Case of a 38 year old patient, presenting blast injury to left proximal femur. Radiological picture by admission: comminuted right proximal femoral fracture with displacement. Multiple metal foreign bodies in soft tissues of the proximal thigh (a). Radiological and clinical appearance of temporary trans-hip bridging using tubular external fixation frame: in the proximal iliac crest two half-pins, in the proximal and distal femoral fragments two and three half-pins were inserted respectively (b,c). Note open postsurgical wounds (d). Six days later freeing of right hip joint, final external femoral fixation with number of additional half-pins to the femoral fragments (e). Clinical picture four weeks later (f).

Discussion

Globally increasing armed conflicts more often attract the interest of emergency surgeons. More than 75% of injuries sustained in modern armed conflicts, are localized to the extremities and greater than one third are comminuted open fractures [10]. High-energy limb injuries, especially in patients suffering from high-velocity gunshot and blast war trauma, result in severe extensive tissue damage or loss, tissue devascularization, creating a high rate of complications and increasing overall morbidity. Rapid, minimally invasive and adequate stabilization after war injuries to extremities is an effective tool to prevent further tissue damage, decrease the hemorrhage and stabilize the patients' general condition [11,12]. A staged treatment protocol, including primary temporary tubular unilateral fixation, followed by definitive bone reconstruction after patients' general stabilization, is an effective method for the management of patients suffered from high-energy war injuries, decreasing complication rates. Benefits of the use of temporary external fixation until the soft tissue envelope has sufficiently healed, followed by definitive internal reconstruction and fixation, have been demonstrated by several authors in treating complex limb fractures [13,14]. Tubular external fixation frames, used in DCO procedures allow enough wound access for second look, providing a good option for vascular and plastic surgery, if needed [15]. In the treatment of patients suffering from complex peri-articular and intra-articular fractures and also extensive peri-articular soft tissue damage temporary trans-articular bridging is indicated. Using these frames in patients with complex open peri-articular proximal femoral fractures due to high-energy war trauma is challenging procedure.

The place of insertion, size and number of the half-pins' are of major importance and mostly are inserted in the supra-acetabular region or in the iliac crest. Two of our patients had inserted supra-acetabular half-pins and four patients had half-pins in the iliac crest. We preferred supra-acetabular half-pins insertion in the pelvis, if it is possible, because of the supra-acetabular bone quality and tighter fixation. Supra-acetabular pins placement was described by Haidukewych et al. They noted that insertion of pins at least 2 cm above the hip avoids potential hip capsule penetration. The pins can be placed accurately and safely using percutaneous techniques, appropriate soft tissue sleeves, and fluoroscopic guidance. Lateral femoral cutaneous nerve anatomy should be taken into account [16]. Increasing half-pins' diameter and their number in each of the main bone fragments increases stability of the fracture fixation.

The lack of long-term results is the main limitation of our case series presentation. All five patients after discharging from our center went to their home country in Syria and due to complex political conditions, these patients were lost to follow-up in our hospital. However, it should be noted that in most of the complex patients of this group, trans-articular hip bridging was performed as the tool of DCO facilitated patients' mobilization and nursing care. It allowed to stabilize the soft tissues envelope, providing an uncomplicated conversion to the final fractures' fixation, having thus fulfilled its purpose.

In conclusion, temporary bridging trans-hip tubular external fixation is recommended as primary skeletal stabilization in complex intra-articular, peri-articular hip fractures or extensive peri-articular soft-tissue damage or loss. This method is a good option during DCO treatment in patients suffered a high-energy trauma, including war high-velocity gunshot and blast injuries.

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