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Outcomes of multiple and combined bone injuries of lower limbs treated with half-pin fixator

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Objective To review outcomes of lower limb injuries repaired with half-pin fixator. **Material and methods** The study included 28 patients with fractured femur and tibia due to multiple and combined injuries treated with half-pin fixator of the own construct. Mean patients' age was 43.4 years (range, 19 to 68 years). The patients were followed up clinically for 12 to 26 months. Mean external fixation period was dependent on consolidation signs and type of fracture. **Results** AO/ASIF type A fractures healed within 12 to 14 weeks and types B and C required 14-to-16-week fixation. Full consolidation was observed in 25 cases (89.3 %). One patient (3.6 %) with bilateral tibial fracture has developed no healing and been followed up. Malunion was noted in 2 cases (7.2 %) due to early frame removal. Three patients (10.7 %) developed pin tract infection that was arrested with locally injected antibiotics at pin sites and changing dressings. **Conclusion** Application of half-pin fixator devised for transosseous osteosynthesis of long bones can be the method of choice for this cohort of patients. The half-pin fixator used to repair multiple and combined injuries can stabilize general condition of the patients and provide the possibility with early ambulation regaining motion in the joints.
Keywords: multiple trauma, combined injury, fracture, femur, tibial bones, external fixation, half-pin fixator

BACKGROUND

Polytrauma is a multi-system injury and a major cause of mortality and morbidity with the mortality rate of 40 % of the cases and disability of 50% [1, 2, 3]. Multiply injured patients with major long-bone fractures require early surgical stabilisation of limbs to prevent such complications as fat embolism syndrome, venous thromboembolism, hypostatic pneumonia in older people, in particular [4]. Surgical treatment must be less traumatic with less stress to the patients. Early stable fixation of long bones is to be performed with less blood loss and early rehabilitation of patients. Parafractural hematoma must be conserved during surgical intervention. External fixation involves application of the above principles to facilitate osteosynthesis of fractures of several injured segments [5, 6, 7].

The aim of our study was to review outcomes of lower limb injuries repaired with half-pin fixator.

MATERIAL AND METHODS

We developed half-pin fixator (patent FAP 00737 dtd 08.06.2012) for osteosynthesis of long bones (**Fig. 1**) containing four arches (3) connected in pairs by threaded rods (4) and cantilever half-pins attached to brackets (1). The device is supplied with middle support in the form of arc-shaped plate with two longitudinal holes (5, 6). Two threaded rods connecting two supports in pairs are attached to the holes at the sides. Brackets with cantilever half-pins attached to them are mounted to the rods (2). The size of the support with holes is greater than that of the rest supports.

Twenty-eight 19 to 68 year-old patients (mean age, 43.4 years) with femoral and tibial fractures resulted from multiple and combined injuries repaired with half-pin external fixator of our own design between 2011 and 2016 were enrolled in the study. From them, there were 21 (75 %) males and 7 (25 %) females. There were 4 A1, 8 A2, 2 A3, 8 B1, 4 B2 and 2 C1 AO/ASIF injuries; 5 (17.8 %) open and 23 (82.1 %) closed fractures. Mechanisms of fracture included road traffic accidents (n = 19, 67.8 %), 7 (25 %) domestic and 2 (7.2 %) outdoor injuries. Combined injury included closed traumatic brain injury (TBI) (cerebral concussion,

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n = 13), closed TBI (cerebral contusion, n = 2), closed fracture of the humerus, injured brachial artery, broken ribs complicated with hemothorax (n = 2). Multiple injury involved tibial fracture combined with vertebral compression fractures of thoracolumbar spine (n = 3); femur and pelvis fractures (n = 2); tibia and humerus injury (n = 2); femur and tibia fracture (n = 3) and bilateral tibial fracture (n = 1). Sixteen patients presented on admission with traumatic shock grade I (n = 9), grade II (n = 4) and grade III (n = 3). Physical examination and radiological assessment were performed on admission. Osteosynthesis was produced within 6 to 10 hours from injury under general or spinal anaesthesia. Primary surgical treatment of the wound and osteosynthesis with half-pin fixator were performed for patients with open fractures. Patients with combined injury to abdomen and limbs required emergency procedures of laparotomy, suture ligation of parenchymal organs and stabilisation of broken long bones with half-pin device produced by two teams. Diagnostic and therapeutic thoracentesis was indicated for 4 patients with lung laceration due to multiply broken ribs. Subdural hematoma was diagnosed in one patient who underwent decompression procedure with favourable outcome. Postoperative period was uneventful. Antibiotic therapy was administered to the patients who were encouraged to exercise hip, knee and ankle joints 2 to 3 days after external fixation. Mean length of inpatient stay was 10.6 days. Pain with the weight borne by the involved leg, range of motion in the knee and ankle joints and pin sites were clinically evaluated in the patients.

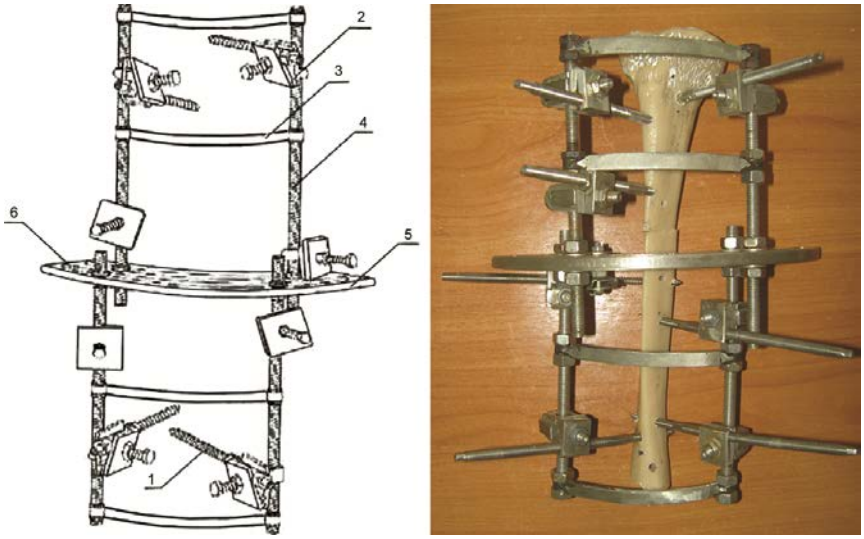

Fig. 1 Half-pin fixator for osteosynthesis of long bones

RESULTS

Short-term outcomes were assessed in all the cases. Complications seen included hypostatic pneumonia (n = 4, 14.3 %), pressure ulcers on sacrum (n = 3, 10.7 %) and pin tract infection (n = 3, 10.7 %). Complications were arrested with changing dressings and/or antibiotic therapy. Long-term results were followed up from 12 to 26 months. After discharge patients were examined every 8 to 10 weeks. Fracture healing was assessed clinically and radiologically. Mean external fixation length was dependent on signs of consolidation and fracture pattern. Mean fixation length was 12 to 14 weeks with fractures AO/ASIF type A and 14 to 16 weeks with types B and C. Full consolidation was observed in 25 (89.3 %) cases. One patient (3.6 %) developed bilateral tibial fractures due to non-compliance and no healing was noted during a follow-up visit. Malunion was seen in 2 (7.2 %) cases due to early frame removal. Outcomes measures included E.R.Mattis evaluation system [15]. Long-term results showed positive outcomes achieved in all the cases with 25 (89.3 %) evaluated as good and 2 (7.2 %) as fair. Poor result was observed in 1 (3.6 %) case.

There is a clinical instance of a 56-year-old male patient who sustained a combined injury as a result of a road traffic accident. The patient was diagnosed with closed TBI, brain concussion, closed comminuted displaced fracture of the mid third of tibial bones (right side) AO/ASIF type 42-

B2.3 **(Fig. 2)**. Transosseous osteosynthesis of the right tibia using half-pin frame of our own design was applied after 12 hours of injury following preoperative preparation stage (**Fig. 3**). The remaining bone displacement revealed radiologically was eliminated by a set of manoeuvres involving bone derotation first and then translation and compression. A course of rehabilitation measures was administered on postoperative day 3. Postoperative period was uneventful and the patient was discharged from the hospital after 7 days showing a satisfactory range of motion in the joints of the involved lower limb. Signs of bone consolidation could be seen after 14 weeks (**Fig. 4** and **5**) and the frame was removed. The patient developed full consolidation of tibia and fibula radiologically (**Fig. 6**) and showed full range of motion in the knee and ankle joints with no complaints at the gait that indicated to a good anatomical and functional follow-up at one year.

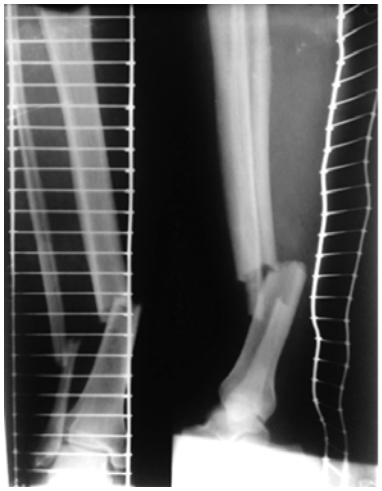

Fig. 2 Preoperative radiographs of the right tibia and fibula of patient M. (two views)

Fig. 3 Two radiological views of the right tibia of patient M. postsurgery

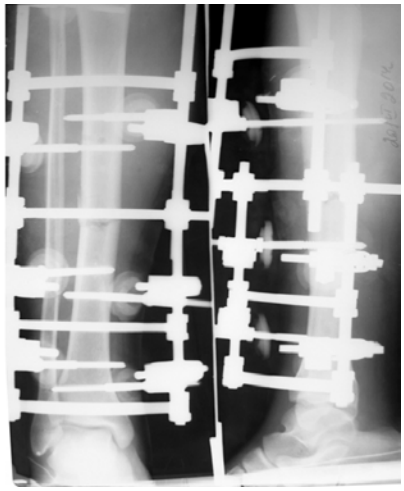

Fig. 4 Radiographs of the right tibia of patient M. 14 weeks after the surgery

Fig. 5 Appearance of patient M. 14 weeks after frame application

Fig. 6 Two radiological views of the right tibia of patient M. at one-year of frame removal

DISCUSSION

The wide array of surgical options available for repair of long bones in multiple and combined injuries fails to meet the demands of current traumatology and orthopaedics pushing for the search of new approaches [8, 9, 10, 11, 12]. Stabilisation of fractures in polytrauma is very important for early rehabilitation of casualties and prophylaxis of secondary complications. The design of our construct is similar to other external

fixation devices including simple usage, short timing of surgical application, less invasive procedure, less blood loss, preservation of nutrient vessels in the involved bone segments and stable fixation [13, 14]. In addition to that, the device is in conformity with biomechanical laws at each level with metal-to-bone distance being equal all throughout the limb due to a stepwise shape of the construct to facilitate stability and fracture consolidation. Less weight is maintained by the fracture site during walking.

Early osteosynthesis with external fixation device applied for long bones fractures in patients with multiple and combined injuries ensured stabilisation of patients' condition and early initiation of ROM exercises in the adjacent joints. Conditions were created to facilitate bone healing with parafractural hematoma and nutrient vessels preserved. Rigid bone stabilisation was helpful in pain relief to contribute to early ambulation and anatomic and functional recovery.

CONCLUSIONS

Application of half-pin fixator devised for transosseous osteosynthesis of long bones can be the method of choice among the known devices. The half-pin fixator used to repair multiple and combined injuries can stabilize general condition of the patients and provide the possibility with early ambulation regaining motion in the joints. The half-pin device can be used to adjust any type of bone displacement ensuring rigid fixation throughout the healing period and maintaining joint function and can be advocated as a practical tool in traumatology and orthopaedics.

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