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Minimally invasive surgical technique: Percutaneous external fixation combined with titanium elastic nails for selective treatment of tibial fractures

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ABSTRACT

Introduction: Several techniques have been described to treat tibial fractures, which respectively remains defects. This article presents a novel intra- and extramedullary fixation technique: percutaneous external fixator combined with titanium elastic nails (EF-TENs system). The purpose of this study is to introduce this new minimally invasive surgical technique and selective treatment of tibial fractures, particularly in segmental fractures, diaphysis fractures accompanied with distal or proximal bone subfissure, or fractures with poor soft-tissue problems.

Methods: Following ethical approval, thirty-two patients with tibial fractures were treated by the EF-TENs system between January 2010 and December 2012. The follow-up studies included clinical and radiographic examinations. All relevant outcomes were recorded during follow-up.

Results: All thirty-two patients were achieved follow-ups. According to the AO classification, 3 Type A, 9 Type B and 20 Type C fractures were included respectively. According to the Anderson-Gustilo classification, there were 5 Type Grade II, 3 Type Grade IIIA and 2 Type Grade IIIB. Among 32 patients, 8 of them were segmental fractures. 12 fractures accompanied with bone subfissure. Results showed no nonunion case, with an average time of 23.7weeks (range, 14-32weeks). Among them, there were 3/32 delayed union patients and 0/32 malunion case. 4/32 patients developed a pin track infection and no patient suffered deep infection. The external fixator was removed with a mean time of 16.7 weeks (range, 10–26 weeks). Moreover, only 1/32 patient suffered with the restricted ROM of ankle, none with the restricted ROM of knee.

Conclusion: This preliminary study indicated that the EF-TENs system, as a novel intra- and extramedullary fixation technique, had substantial effects on selective treatment of tibial fractures.

Introduction

With vulnerable soft tissue coverage, the tibia is an exposed bone and easy to fracture when got injured, even under low-energy violence. The correct handling of soft-tissue, satisfactory reduction and stable fixation are urgent problems in tibial fracture treatment [1–5]. There are many optional treatments to tibial fracture, but each has its own weakness, which remains controversial [6–16]. Traditional open reduction and internal fixation can achieve satisfactory reduction and stable fixation, while the risk of increasing soft-tissue injury and the high rate of bone healing complications are more likely related [6,7]. Intramedullary nailing (IMN) is also an optional technique. But the side effects, such as postoperative knee pain, destruction of the endomedullary blood supply with more hidden blood loss, iatrogenic propagation of the fracture, inadequate distal fixation and hardware failure leading to malunion, should be taken into consideration [8–10]. The external fixator (EF) has a defined place in the primary treatment, for its

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simple process, slight soft-tissue affection, no periosteal stripping and less blood-supply destruction in the fracture site [4,11,12]. However, pin track infection, delayed union, malunion, and non-union remain the main complications associated with external fixator [13–15,24,25], probably due to either poor initial reduction and stable fixation or later loss of reduction. For these reasons, it merely be used as a temporary way in some severe fractures or accompanied with multiple injuries, and often needs a secondary operation, adopting more stable fixation methods [10,16]. Therefore, against these situations, we develop a novel intra- and extramedullary fixation technique: percutaneous external fixator combined with titanium elastic nails (EF-TENs system). In this system, the titanium elastic nails, with closed reduction, can play a certain role in maintaining fracture linear and rotational stability with good elasticity and flexibility as possible [17–19]. The purpose of this study is to introduce this new minimally invasive surgical technique and selective treatment of tibial fractures, particularly in segmental fractures, diaphysis fractures accompanied with distal or proximal bone subfissure, or fractures with poor soft-tissue problems.

Materials and methods

Patient date

With approval by the ethics committee of the Second Affiliated Hospital of Wenzhou Medical University, between January 2010 and December 2012, this approach was introduced in the treatment of 32 patients (20M/12F), with a mean age of 48.1 years (range, 20–73 years). All patients were older than 18 years, and they were all complete extra-articular fractures, including 22 closed fractures and 10 open fractures, with or without concomitant fibula fracture. According to the AO classification, 3 Type A, 9 Type B and 20 Type C fractures were included respectively. According to the Anderson-Gustilo classification, there were 5 Type Grade II, 3 Type Grade IIIA and 2 Type Grade IIIB. Among 32 patients, 8 of them were segmental fractures. 12 fractures accompanied with bone subfissure. Patients with pathological fracture or other metabolic bone diseases in this study were excluded. Three patients were involved additional injury(s), the one associated with pulmonary contusion and slight pleural effusion, another two both with ulnoradial diaphyses fracture. The closed fractures without any complication underwent surgery at an average of 1.7days (range 1–3 days). The open fractures underwent initial debridement and then followed by the EF-TENs system in an emergency operation within 8 h.

Description of the system

The EF-TENs system contained a unilateral orthofix external fixator and two titanium elastic nails (TENs). The unilateral orthofix external fixator (Orthofix Srl Inc., Italy) equipped with four screws, part with hydroxyapatite (HA) coating on. The TENs (Synthes Bettlach Inc., Switzerland), come with a bevelled blunt tip 2.0–4.0 mm in diameter, and could be selected according to different patients.

Surgical technique

The fixation of a concomitant fibular fracture

Fibular fixation had certain significance in stability and healing of tibial fracture [20]. If tibial fracture was serious, firstly fixing the fibula could contribute to recover length and preliminary reduction. Otherwise, we fixed tibial fracture and then treated the fibula.

If the patient was accompanied with a fibular fracture, a 2.0–4.0 mm diameter of titanium elastic nail (TEN) was retrogradely inserted through the tip of the lateral malleolus percutaneously.

The fixation of tibial fracture

The operation was performed under spinal or general anaesthesia using the supine position. Adequate radiological evaluation was required, and anteroposterior and lateral views were available.

Firstly, the preliminary closed reduction was performed under C-arm fluoroscopy, for the purpose of diminishing the deformities of rotation, angulation and severe shortened displacement. The TENs were then inserted in an anterograde or retrograde direction according to soft tissue situation of the enter point positions and distal or proximal occult fracture. The TENs had a bevelled blunt tip and the tip was then approximately bent to 45 to ease its passage along the opposite cortex and to aid in fracture reduction. At lateral and medial of the proximal (anterograde) or distal (retrograde) tibia, positioned with fluoroscopy, a 1–2 cm longitudinal incision was made. Under fluoroscopic guidance, the soft tissues were bluntly dissected and a tapered awl was used to bore through cortex at oblique angle. Then, we inserted the pre-bent nails while rotating them into the incision along the diaphysis, across the fracture site, and into the distal to effect an anatomical reduction as possible. The second nail was inserted from the other side in the same way. With fluoroscopy in both the anteroposterior and lateral views, finally confirmed that the TENs and fracture locations were satisfied. The nail ends left outside the skin were clipped, leaving only a length of 1-cm from the cortex.

After the initially reduced and stabilised the fracture, installing unilateral orthofix external fixator came into operation. Under fluoroscopic control, the external fixator was applied where two screws were inserted proximally and distally respectively. The size of tibial marrow cavity was different at each level, and the screws of external fixator would probably fail to thread marrow cavity due to the nails blocking. The tip was that the first screw should be fixed where tibial marrow cavity was relatively narrow, and the medullary cavity of other three screws is larger, which has more space for screws adjustment in order to install the fixator easily. Usually, the 2nd screw or the 3rd screw should be fixed at first (Fig. 1B–D). After fixing the first screw, we fixed the second screw in parallel with the first one and the distance of the two screws in one lateral model should be as far as possible in allowed range. Under fluoroscopy, all screws must be threaded the opposite cortex to guarantee stability. Last, the external fixator was then attached to the screws. If there was still slight angulation or shortened displacement, tried to regulate by ball joints and compressive rod, and then tightened up all bolts.

For open fractures, thorough debridement and irrigation of wound were carried out in operation room. All necrotic or contaminative tissues were excised, and broad spectrum antibiotics were started as early as possible. As to soft tissue coverage failure, they were covered with Vacuum Sealing Drainage (VSD).

Follow-up study

Follow-up time was at 2 weeks, 4 weeks, 2 months and 3 months postoperatively, and then at 2 months intervals, including clinical and radiographic examinations. During the visit, make sure whether infections existed according to wound or pin track condition. Follow-up radiographs were used to evaluate fracture position, bone contact and callus formation. At the first 4–6weeks after the operation, patients were required stay in bed or when the wound condition turned satisfied and postoperative swelling was relieved, they were allowed non-weight-bearing. Once callus formed, we loosened compressive rod, generating dynamisation at fracture site. Patients were then allowed touch-weight-bearing exercise