Treatment of complex tibial plateau fractures using Ilizarov external fixator with or without minimal internal fixation

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Background
The tibial plateau is a critical weight-bearing area located on the upper end of the tibia. The lesion may be restricted to the tibia or associated with significant soft-tissue injury. The aim of the present study is to assess the results of closed reduction and Ilizarov external fixation in management of comminuted tibial plateau fractures.
Patients and methods
The study included 20 patients with high-energy tibial plateau fractures (Schatzker types V and VI). The ages ranged from 23 to 56 years, with an average of 30 years. The trauma was a road traffic accident in 11 cases and a fall from a height in nine cases. The fractures were closed in 16 cases and open in four cases. The open fractures were Gustilo–Anderson type I in one case and type II in three cases. Soft-tissue injuries associated with closed fractures were classified according to Tscherne system. The follow-up period averaged 31 months. The mean duration of surgery was 70 min (range: 40–120 min). The mean time to union was 10.4 weeks. At the final follow-up, the average total range of knee flexion was 112.5° (range: 0–170°).
Results
Results were satisfactory in 18 cases and unsatisfactory in two cases according to the Rasmussen knee functional score. Complications included pin-tract infection in 12 cases, an extension lag in two cases and varus deformity of about 15° in one case.
Conclusion
Hybrid external fixation is a good method for the treatment of comminuted tibial plateau fractures. It allows for early joint movement and reduces the risk of serious complications.

Keywords:
complex intra-articular, Ilizarov external fixator, tibial plateau fractures

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Introduction

Bicondylar tibial plateau fractures are often associated with severe soft-tissue injuries that can affect the results of treatment. Operative management of these injuries is invariably complicated by the condition of the soft-tissue envelope of the proximal tibia [1].

A biological approach to the soft-tissue envelope of the proximal tibia can help minimize some of the complications that often follow surgical intervention [2].

The aim of this study is to evaluate the hypothesis whether the minimally invasive technique of Ilizarov external fixator with minimal internal fixation in tibial plateau fractures can provide a satisfied outcome with few complications. Particular attention is paid to the functional outcome of, and complications associated with, this treatment method.

Patients and methods

Between February 2008 and March 2010, twenty patients with high-energy bicondylar tibial plateau fractures were managed with the use of Ilizarov circular external fixator. There were 12 men and eight women. The mean age was 30 years (range: 23–56 years). Exclusion criteria were patients with concomitant injuries that could alter the functional outcome of the patient – for example, ipsilateral femoral shaft fracture, ipsilateral acetabulum fracture and bilateral fractures. Six patients met these criteria.

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The mechanism of injury was a road traffic accident in 11 cases and a fall from a height in nine cases. The fractures were closed in 16 cases and open in four cases. The open fractures were Gustilo–Anderson type I in one case and type II in three cases. Soft-tissue injuries associated with closed fractures were classified according to the Tscherne system (Table 1) [3]. Eleven fractures were Schatzker type V and nine cases were type VI [4]. Computed tomography was performed in all cases to assess the degree of comminution, the amount of depression and to detect the main fragments through which the screws could be inserted.

Prophylactic antibiotics were administered intravenously in all cases. In the open fracture cases, antibiotics were prescribed as necessary for the first days and subsequently replaced according to the culture results. All open fractures initially received a combination of a second-generation cephalosporin with an aminoglycoside.

The procedures were performed under spinal anaesthesia. The patients were positioned supine on a radiolucent fracture table. Reduction was achieved with traction given by the assistant, and manipulation was done by the surgeon. The fracture reduction was visualized with an image intensifier. Through a small incision over the anteromedial aspect of the tibial metaphysis, a small 'window' was made in the tibial cortex in nine cases. A blunt-tipped curved 3-mm K-wire or a simple pusher was inserted through the hole, up to the articular fragments, which were elevated under the image intensifier control. Bone grafts were applied to feel the osseous gaps in three cases. After achieving adequate reduction, three K-wires (1.8-mm thick) were placed in the juxta-articular bone parallel to the joint line. Each wire was positioned centrally in the major fracture fragment and perpendicular to the major fracture lines so as to hold the reduction. These wires are tensioned over an appropriate-sized ring. A preassembled tibial frame consisted of two appropriately sized rings, and the distal ring was placed 2–3 cm proximal and parallel to the ankle joint. The proximal ring of this frame was placed 2–3 cm distally to the fracture. Three tensioned wires were attached to each ring. Finally, the distal preassembled frame is connected to the proximal ring using four treaded rods to reduce the diaphyseal portion of the fracture to the metaphyseal one. Additional fixation was done with percutaneously placed 4 or 6.5 mm cannulated cancellous screws to achieve intercondylar compression in nine patients.

A femoral frame was applied in three cases for marked fracture comminution necessitating a more proximal stability over the knee.

Postoperative care

Isometric quadriceps exercise was started from postoperative day 1. Early knee motion was encouraged from the first week. Touch-down weight bearing was allowed initially and then advanced to partial weight bearing as tolerated as possible at 3 weeks. Full weight bearing was allowed when complete union was achieved within 4 months. Serial radiographs were taken at 4-week intervals to detect any deviation of mechanical axis and union, which was defined as obliteration of the major fracture lines in both views (Fig. 1a–c).

Pin site was cared daily with alcohol. After the bone had healed, frame dynamization was done. The external fixator was removed under anaesthesia. After removal of the external fixator, clinical and radiological evaluations were made every 3 months for the first year and then every 6 months until final follow-up. The results were evaluated according to the Rasmussen knee functional score [5].

The patients' satisfaction was evaluated through an interview in which they subjectively reported their level of satisfaction (from full satisfaction to dissatisfaction). The patients' level of satisfaction was assessed by asking them how they felt after the surgical procedure compared with how they felt before the operation [6]; whether they would go through the procedure again [7] and whether they would recommend it to other people who sustained a similar fracture [8].

Table 1 Soft-tissue injury was classified according to Tscherne system and open fractures were classified according to Gustilo–Anderson system

Associated soft-tissue injuries	Number of patients
Tscherne grade I (superficial abrasion/contusion)	7
Tscherne grade II (deep abrasion with skin or muscle contusion)	5
Tscherne grade III (extensive skin contusion or crush, severe damage to the underlying muscle)	4
Open grade I compound fractures	1
Open grade II compound fractures	3

Figure 1

(a) Preoperative anteroposterior and lateral views showing comminuted fracture of the tibial plateau. (b) Fixation of the tibial plateau with the Ilizarov external fixator. (c) Radiograph showing fracture healing.

Results

The follow-up period averaged 31 months (range: 18–45 months).

There was no incidence of nonunion, septic arthritis or deep-vein thrombosis. The mean time of union was 3.2 months (range: 2.5–3.5 months).

According to the Rasmussen knee functional score [9], the results were excellent in five cases, good in 12 cases, fair in two cases and poor in one case.

The mean duration of surgery was 100 min (range: 80–150 min). The mean trauma to surgery interval was 23 h (range: 5–74 h). The average hospital stay was 11 days.

The external fixators were removed on an average of 3.5 months (range: 2.8–5 months) without additional immobilization. Skin graft coverage was needed only for one patient. The average total range of knee flexion was 112.5° (range: 0–170°), but three patients had a total arc of motion less than 60° and two of them had a femoral extension of the fixator. All patients received physiotherapy after removal of the frame. An extension lag was a common finding. It was observed in five cases; however, they showed gradual improvement of range of motion that was compatible with a normal gait within 6 months. One patient had a positive anterior drawer test but without functional instability. None of the cases had mediolateral instability. At final follow-up, radiographs showed articular depression more than 3 mm in three (15%) cases and less than 3 mm in four (20%) cases. The quality of reduction increased the functional score. The patients' satisfaction was significantly related to the functional results ($P < 0.05$). In 20% of the cases, pin-site infections were observed. These infections were superficial or limited to the soft tissue. It was controlled by frequent dressing and local antibiotics. No loss of reduction occurred after removal of the fixator.

Axial deviation (varus deformity) was observed in one patient early (1 week postoperatively), and this was corrected by modification of the frame assembly under general anaesthesia. One patient united in 15° varus alignment.

Discussion

The keys to successful outcome for the bicondylar tibial plateau fractures are to restore the articular cartilage, preserve the biology and obtain a painless, mobile and aligned knee joint [10,11].

Open reduction and internal fixation was considered to be the best mechanical method of stabilization for bicondylar tibial plateau fractures. It has the advantage of an accurate reduction and stable fixation. However, it carries the risk of further soft-tissue damage and infection [12–15].

Not all bicondylar tibial plateau fractures will reduce with ligamentotaxis alone, and a limited open

reduction with minimal periosteal stripping is sometimes necessary [4]. In our study, limited open reduction through a 5–6-cm incision was needed in nine cases, whereas bone grafting to support the elevated articular surface was needed in three (15%) cases. This is comparable to the study of Morandi and Pearse [10] who reported elevation and bone grafting in 26% of cases in a series of 50 complex plateau fractures treated with Ilizarov fixation. Several authors have identified factors that maximize the chances of a favourable outcome. These factors include the amount of damage to soft tissues and articular cartilage, the accuracy of reduction, the stability of the knee joint, the stability of fixation and the overall alignment of the limb [17,18]. All of these factors should be optimized in the care of tibial plateau fractures. Most of the reports include only low-energy or very few high-energy fractures. There is little reported information that focuses on the results of treatment of high-energy fractures.

The magnitude of soft-tissue injury was also an important predictor of functional outcome. The technique for bicondylar fractures was originally performed through a single anterior incision, with subperiosteal dissection of the proximal tibia on both medial and lateral sides. This massive soft-tissue stripping leads to devascularization of bone and a high rate of infection. Infection rates markedly decreased and outcomes greatly improved when a less invasive technique was used; however, the risk of deep infection and soft-tissue complications is still present [19]. Lee *et al.* [20] reported on 36 tibial plateau fractures treated with the less invasive stabilization system. Two of them had deep infection and one had extended skin necrosis and required plastic surgery. Most of the authors who had good results with internal fixation of such fractures have used the external fixator as a preliminary step to help soft-tissue healing before internal fixation [21]. We prefer to use the external fixator as a definitive line of treatment and to avoid exposure to another surgery. Fixation of the fracture using Ilizarov circular fixator avoids extensive soft-tissue dissection.

In a series by Dendrinos [22], 24 patients were treated with the Ilizarov circular fixator, and there was no incidence of osteomyelitis or septic arthritis. Chin *et al.* [17] reported similar results of 18 patients, none of whom developed wound dehiscence, infection, osteomyelitis or septic arthritis. The current series is comparable to these studies in that no cases of wound dehiscence, infection, osteomyelitis or septic arthritis were encountered.

Recent biomechanical studies proved that the fine-wire fixator provides adequate mechanical stability for the fixation of the bicondylar tibial plateau fractures. Ring fixator provides good purchase in soft cancellous bone. The tensioned wires function as a scaffold in buttressing the subchondral bone, restore the intrinsic stability of the fracture site with a bridge device and allow the patient to transfer his or her body weight through the scaffold to allow early weight bearing.

The timing of surgery is one of the factors affecting the final outcome. This factor is one of the factors that can be controlled. In this study, we operated our cases as early as possible to avoid development of oedema and to allow early soft-tissue recovery. Zura *et al.* [19] and Hak *et al.* [18], however, believed that early surgical reduction and firm fixation could retard further injury to local soft tissues. We deem that the majority of the soft tissues around fractured tibial plateau have a relatively mild swelling within 12 h after injury. Therefore, internal fixation is considered eligible at this period, provided that local skin tension is not too high.

Varus deformity was observed during the follow-up in one of the cases. Circular external fixator offers the unique possibility of correcting acutely or gradually any residual axial deviation at any plane, even torsional deformities.

Conclusion

Decreased incidence of soft-tissue complications, early range of motion, early weight bearing and good functional recovery all compare favourably with other reported results and substantiate the recommendation that external fixation should be the treatment of choice for such injuries.

A possible further advantage of this treatment modality is the fact that minimal dissection is performed and minimal metal ware is left *in situ*.

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Conflicts of interest

There are no conflicts of interest.

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