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MODIFIED HYBRID FIXATOR FOR HIGH-ENERGY SCHATZKER V AND VI TIBIAL PLATEAU FRACTURES

Orthopaedics

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ABSTRACT

Associated high-energy tibial plateau fractures with severe soft tissue injury and communition prove a challenge in management. The risk of wound complications after open reduction and internal fixation is considerably high thanks to the extensive soft tissue dissection. Alternatively, the application of a hybrid external fixator minimizes the soft tissue dissection and provides adequate fracture stabilization to allow early extremity movement and correction of any misalignment. With this technique, soft tissue complications, especially surgical ones like infections at the site are expected to be significantly reduced. This prospective study after aims to determine the efficacy of a modified hybrid external fixator in the management of high-energy fractures of the tibial plateau. Twenty-two patients with a high-energy fracture of the tibial plateau Schatzker V and VI with severe soft tissue injury precluding formal opening reduction were included in the study. The fixator was a construct combining an Ilizarov ring with a mono-lateral external fixator. Results – union of bones, range of motion, and treatment-related complications were noted. All fractures united within an average time of 13 weeks. Neither loss of reposition nor osteomyelitis was noted. Three patients developed superficial pin-track infection which was treated by per oral antibiotics. One patient developed deep venous thrombosis and one developed local skin breakdown. A hybrid external fixation is a safe option for complex high-energy tibial plateau fractures by simultaneously ensuring adequate fracture stabilization and protection of soft tissue healing to achieve bony union. The complications are mainly related to infection of the pin tract.

KEYWORDS

Hybrid external fixator, Severe soft tissue injury, High-energy tibial plateau fractures, Schatzker type V and VI.

INTRODUCTION

Although biomechanically, dual plating is the best stabilization option for Schatzker V and IV high-energy tibial plateau fractures, it requires extensive soft tissue dissection with a potentially high rate of postoperative complications, especially if a single midline incision is used for dual plating [1–4]. Schatzker V and IV fractures are complex fractures often associated with severe soft tissue injury and a high risk of wound complications after formal open reduction and internal fixation [3]. The difficulty of treatment is further exacerbated by the problem of choosing a stabilization option to ensure stable fixation of a commonly comminuted fracture. Recently though, hybrid external fixation has been promoted. Early experience seems to indicate its effectiveness in the treatment of these difficult fractures [2, 5–8]. It relies on the construction of a peri-articular ring for stable fixation of the tibial condyles and a mono-lateral fixator for fixation on the diaphysis to ensure a stable fixation block. It has been shown to provide adequate stability to maintain the fracture position without the need for massive soft tissue dissection, thereby minimizing potential soft tissue complications. The design enables early joint mobilization, cartilage regeneration, and joint remodeling, which in turn reduces the risk of joint stiffness. Commercially available hybrid external fixators are expensive, and the need to use these fixators in patients for an extended period has created a problem related to their cost-effectiveness. This led us to innovate a cheaper and readily available hybrid external fixator construct by combining the Ilizarov ring with a monolateral external fixator system (Fig. 1, 2). This study highlights the technique and results of the treatment using this modified hybrid external fixation to treat this injury.

MATERIALS AND METHODS

The indication for this method of treatment was Schatzker V and VI tibial plateau fractures with associated severe soft tissue injury Tscherne grade 2/3. Our method of treatment was reserved for the most severe tibial plateau fractures presenting at our institution. Fracture patients associated with vascular injuries and those who have been assessed as incompetent in the ability to take care of the fixator because the method requires patient cooperation in the form of pin-site care and aseptic dressing were excluded. This prospective study was conducted from July 2019 until February 2022. 22 patients with complex tibial plateau fractures were included out of which, 19 were men and 3 were women. Most injuries were caused by motor vehicle accidents. There were 16 of them Schatzker-V and 6 Schatzker-VI injuries. Gustillo Anderson grade IIIA open fracture occurred in one patient and 3 patients had severe soft tissue closure injury.

Figure 1: Modified hybrid external fixator

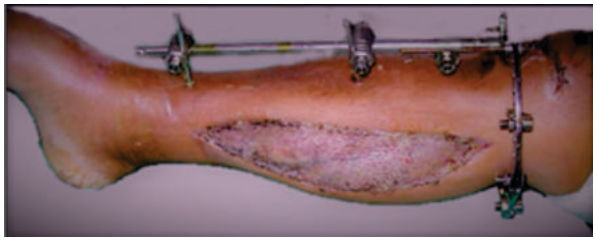


Figure 2: Clinical application

The operation was performed under the cover of spinal anesthesia mostly with 1 case in general anesthesia. A radiolucent operating table and fluoroscopy were used to facilitate the operation. There were fragments leveled by simple manual traction by an assistant. The condylar fragments were compressed with large tenaculum forceps or pelvic reduction forceps and fixed with 6.5 mm cannulated screws or long 4.0 mm screws depending on the size of the fragment. Failure in the reduction of articular fragments or the presence of articular depression often requires open reduction through a small anteromedial or anterolateral approach to elevate the articular surface using a blunt end metal suction tip (Fig. 3). Two 1.8 mm wires were introduced in the safe zone, 15 mm from connector [9] . The minimum angle between them being 60°, oriented as oblique wires was taking into account anatomical limitations. The ring was attached and the wires were tensioned. The meta-diaphyseal alignment was corrected and two Schanz pins were inserted into the diaphysis. Schanz pins were attached to the external fixation rod that was then attached to the ring with an external fixator clamp (Fig. 1). Alignment was again checked under fluoroscopy in both the standard anteroposterior and lateral views. The fracture was reduced by closed means in the 8 patients. Bone grafting was not used at all. All patients were taught to take care of the external fixator and taught to do a daily pin cleaning at the pin sites with hydrogen peroxide. All patients started a passive range of motion exercises on the first postoperative day and active movement at the end of 1 week. The patients were started on non-weight bearing mobilization for 6-8 weeks and partial weight-bearing walking was allowed depending on the amount of callus formation at follow-up. After the fixator was removed, full weight bearing was allowed.

Figure 3: Pre op Radiographic AP and Lateral views

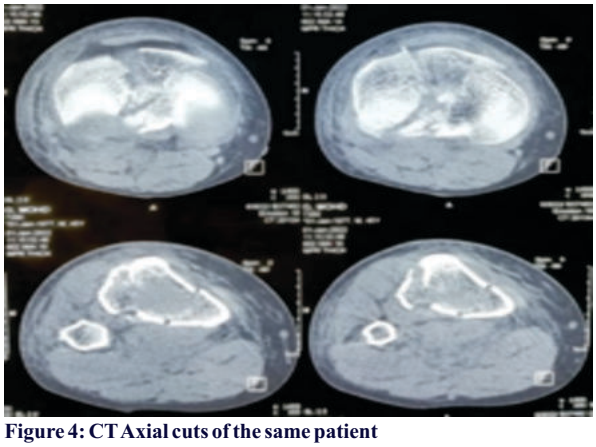


Figure 4: CT Axial cuts of the same patient

Figure 5: CT Coronal and Sagittal cuts of the same patient

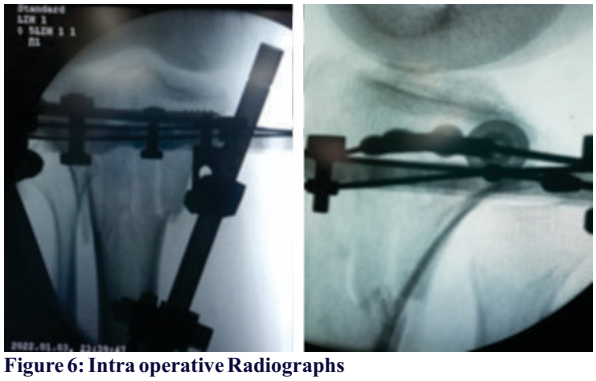


Figure 6: Intra operative Radiographs

Figure 7: Immediate Post- Operative Radiograph

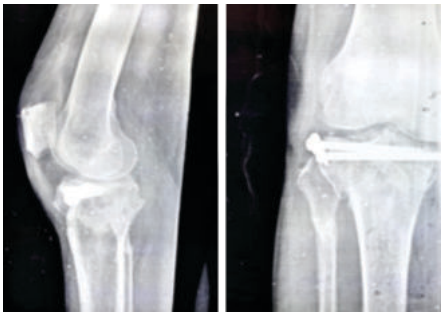


Figure 8: Patient at 3 month follow-up

Serial standing radiographic examinations of the knee and the tibia in AP and lateral planes were performed at 6 weeks, 3 months, 6 months, and 1 year postoperatively.

During observation, two members of the study group assessed patients in terms of the range of motion, fracture union clinically as well as radiologically (Fig. 8, 12), any radiological loss of reduction, any hardware related complications such as wire breakage, clamp failure, surgical infection, osteomyelitis and complications related to surgery as a nerve injury from inadvertent pin placement. The functional score according to Rassmussen [10] was evaluated at 6 months and 1 year.

Figure 9: Another patient with pre-operative Radiograph AP and Lateral views

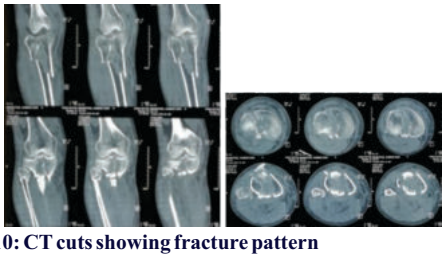


Figure 10: CT cuts showing fracture pattern

Figure 11: Immediate post-operative Radiograph showing Antero-posterior and Lateral planes

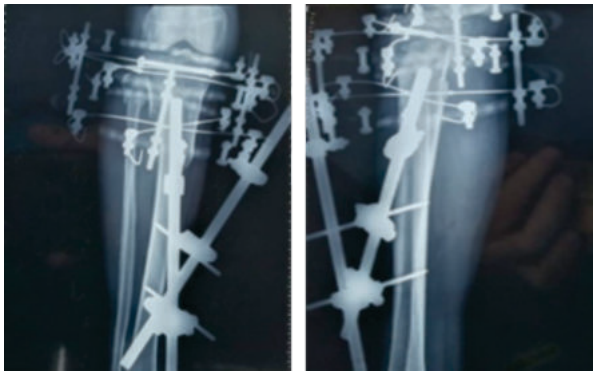


Figure 12: AP and Lateral Radiographs at 6 months follow up

Statistical Methods: The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Categorical variables were summarized as frequencies and percentages. Graphically the data was presented by pie diagrams.

RESULT

The average age of the patients at the time of the injury was 38 years (range 19-59). The average length of hospitalization was 12 days (range 7–18 days). Fractures united in an average duration of 13 weeks (range 9–21 weeks). Two fractures had a varus malunion ((one with a 14o (Rasmussen knee score of 20) and another with 11o varus (Ramussen's knee score of 25)). The average duration of fixator use was 13 weeks (range 9–21 weeks). Patellar tendon bearing casts was used in one patient who had concomitant ipsilateral open tibial midshaft fracture after the removal of the external fixator.

Figure 13: Radiograph at 6 months follow up with Ex Fix and Ilizarov ring removed

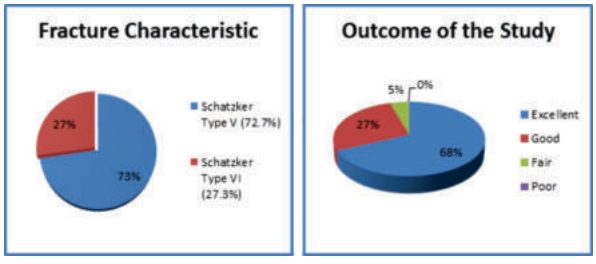
Three patients developed a superficial pin track infection on the wires through the proximal ring. The infection was controlled by local care of the pin site and oral cefuroxime. . Most importantly there were no cases of osteomyelitis. There was one case of a patient developing deep vein thrombosis and one developing local skin necrosis. In none of the patients, there was an injury to the blood vessels or injury to the common peroneal nerve secondary to unintentional Kirschner wire penetration. Another operation was indicated in a patient who required fixation for avulsed PCL 1 month after the first surgery.

Figure 14: Clinical photographs showing bilaterally comparable flexion, extension and ability to sit cross legged at 6 months follow - up

Table: Fractures' characteristics, complications and results of our study.

Patient no.	Schatzker type	Open/ Closed	Results	Complications
1	V	closed	excellent	None
2	V	closed	excellent	None
3	V	closed	good	pin track infection
4	V	closed	excellent	None
5	V	closed	excellent	None
6	V	open	excellent	None
7	V	closed	excellent	None
8	V	closed	good	None
9	V	closed	excellent	deep venous thrombosis
10	V	closed	excellent	None
11	V	closed	good	None
12	V	closed	excellent	None
13	V	closed	excellent	None
14	V	closed	excellent	None
15	V	closed	excellent	None
16	V	closed	excellent	None
17	VI	closed	good	None
18	VI	closed	excellent	pin track infection
19	VI	open	fair	local skin necrosis
20	VI	closed	excellent	None
21	VI	open	good	pin track infection
22	VI	closed	good	None

The mean flexion achieved was 115o (range 90–135o). Five patients had a lag extension of 10–20o. At the 12-month follow-up, 11 patients (50%) had an excellent Rasmussen's knee functional score [10] (27 points or more) (Fig. 14), 8 patients (36.3%) had good functionality (20-26 points), and three patients (13.63%) had fair scores (10–19 points). A fair result was probably due to the accompanying PCL avulsion.



DISCUSSION

In 1979, Schatzker et al. introduced a classification for tibial plateau fractures that distinguished low-energy fission depression fractures from higher-energy bicondylar (Schatzker V and VI) fractures [11]. Many authors have attempted to define these complex fractures based on bone damage or degree of soft tissue damage [12–14].

Objectives of operative treatment of these fractures include an anatomical reduction for joint restoration match and alignment and stable fixation to enable timely movement. However, the classic two-plate osteosynthesis has been associated with potentially devastating complications such as fixation failure, malunion, nonunion, joint stiffness, secondary post-traumatic arthrosis, infection, and most important serious soft tissue complications ranging from 23 to 87.5% [1–4, 14] .

Over the past few decades, the line has evolved treatment modalities from traction to cast immobilization to open reduction and internal fixation used with mixed results. No treatment modality produced consistently good results, nor did any provide both stable fixation and preservation of the remaining soft tissue [2,3] . Many surgeons strive to achieve both stable fixation and preservation of the remaining soft tissue they chose to use indirect reduction and external fixation. Watson eloquently defined the high-energy tibial plateau fractures based on the presence of a large degree of articular depression, displaced multiple condylar fracture lines, and meta-diaphyseal comminution or extension in connection with open wounds or extensive soft tissue injury [15]. These injuries were also labeled as "severe or complex fractures".

Hybrid external fixation was introduced and demonstrated to be effective in treating these difficult fractures [5–8] .Watson et al. the term hybrid fixation is completely valid freely stating that hybrid fixation does not indicate any individual or generally accepted treatment strategy or device [16]. The term hybrid has also been used when the pins are Schantz mounted on a frame distal to the diaphyseal fragment fixation. Kumar and Paige distinguish the conventional Ilizarov frame from the hybrid Ilizarov frame using Schantz pins rather than wires through the distal ring for fixation diaphysis [17]. With the development of technology and hardware used, current hybrid frames consist of small tension wires on the proximal ring frame to maintain a reduce the metaphyseal fragments, while the rest of the distal frame is attached to the shaft as a standard half pin of the external fixator [18]. Indications for hybrid external fixation are Schatzker Fractures of tibial plateau V and VI, prominent metaphysic comminution with or without diaphyseal extension, severe metaphyseal and subchondral comminution with very small periarticular fragment unsuitable for internal fixation, soft tissue problems such as compartment syndrome, open fractures and severe soft tissue injuries in osteoporosis patients [5, 18]. The hybrid external fixator offers several benefits that include minimizing further damage to soft tissue envelope, feasible surgery even in the presence of severely injured soft tissues, adequate stability, early postoperative mobilization, and reduced risk of stiffness. Disadvantages include the need for prolonged pin site care, pin site infection, and risk of septic arthritis from accidental intraarticular pin placement and potential risk of common peroneal nerve injury from poor pin placement.

In a matched cohort study on the treatment of high-grade tibial plateau fractures comparing internal fixation and a ring fixator, Veri et al. [20]. recorded high rates of wound complications and reoperation in open reduction and internal fixation using a simple incision with two plates group. Their results also indicated that hybrid ext fixation is an effective and safe method with low wound complication rates and early functional return.

Infection of the pin tract was a major drawback with the use external fixator for the treatment of fractures. In a meta-analysis of 10 studies with a total of 381 patients, Hutson et al. encountered 38 cases of superficial pin tract infection (10%), 5 septic arthritis (1%), and 13 deep infections (4%) [19]. Our rate of infection of the needle tract was higher when these pins were inserted into already disturbed soft tissues. However, we feel that it is reasonably acceptable to treat pin tract infection rather than massive postoperative soft tissue breakdown as a result of a poorly planned incision on already devitalized soft tissue. Septic arthritis is a rare complication resulting from the use of this technique. It has to do with pin or wire placement in the capsule of the knee joint. It can safely be avoided by placing the most proximal pins or wires 14 mm below the connector [6].

Gaudinez et al. reported the use of the Monticelli-Spinelli hybrid frame only for the indirect reduction technique in a series of 18 Schatzker V and VI tibial plateau fractures [9]. They recommended this technique because of its advantage of minimal soft tissue complications and allowing early range of movement.

CONCLUSION

The degree of soft tissue injury associated with a tibial plateau fracture is an important determinant of both the selection of treatment modality and the prediction of treatment outcome. Our modified hybrid external fixator is a safe and effective treatment option for difficult Schatzker V and VI fractures of the tibial plateau. It minimizes soft tissue complications and promotes the union of bones with an acceptable functional return. The complications are mainly related to pin tract infection. We feel the technique deserves a place in the management of complex fractures of the tibial plateau.

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