



## **Result of Ring Fixator in High-energy Schatzker Type VI Fractures of Proximal Tibia**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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### **ABSTRACT**

**Background:** Significant articular depression, separation of both condyles, diaphyseal comminution and dissociation, and loss of soft-tissue envelope integrity are all associated with high-energy proximal tibia fractures (Schatzker VI). Over the past 50 years, there has been a lot of research on plating problems in these complicated fractures. For the care of these complex injuries, Ilizarov devised a new method (ring fixator).

**Aim of the Study:** To examine the outcomes of patients who received a ring fixator for the treatment of high-energy proximal tibia fractures (Schatzker VI).

**Materials and Methods:** Fourteen patients (mean age 36) were treated with the Ilizarov fixator and transfixion wires for high-energy fractures of the proximal tibia (Schatzker VI). Nine of the patients

had open fractures, and five of them had significant soft tissue damage. They were all tracked for an average of 19.4 months. The result was analyzed using the criteria set by Honkonen & Jarvinen (1992).

**Results:** Thirteen fractures healed in an average of 14.6 weeks, with one taking six months. Twelve patients recovered complete extension, while eight others regained more than 110 degrees of flexion. All of the patients knees were stable, except one who had a minor varus deformity. Nine patients walked normally, while four had a little limp. Except for one, all of the knees exhibited an articular step-off of less than 4 mm and normal axial alignment. Six knees were found to be outstanding, five to be decent, and three to be fair. There were no instances of postoperative skin infection or septic arthritis, however, three patients did have a pin tract infection that was effectively managed.

**Conclusion:** The technique is suitable for the treatment of complex proximal tibia fractures when there is substantial comminution at the fracture site as well as soft tissue damage (Schatzker VI).

*Keywords: external fixator; tibial plateau; schatzker VI; Ilizarov; fractures.*

## 1. INTRODUCTION

Complex proximal tibial fractures, especially tibial plateau fractures, are one of the most challenging problems in fracture surgery [1-3]. Schatzker et al. identified six types of tibial plateau fractures in 1979 using anteroposterior radiographs [4]. Schatzker type VI tibial plateau fractures are caused by severe high-energy trauma. The proximal tibia exhibits a transverse or oblique fracture in combination with a fracture of one or both tibial condyles and articular surfaces. Bones and soft tissues are severely damaged by tremendous energy. In addition, these high-energy injuries cause serious articular depression, condylar displacement, including meta-diaphyseal fracture extension with open wounds or severe closed degloving injuries of the tibia [5]. Complications include severe soft tissue covering problems, lower limb compartment syndrome, peroneal nerve damage, vascular injury, and final knee arthrosis [6] These issues have an immediate impact on surgical decision-making and prognosis. The therapeutic concepts include anatomical reconstruction of the articular surface, restoration of the anatomical axis, fixation across the metaphyseal comminution, and further minimization of harm to an already injured soft tissue environment [7]. To accomplish these objectives, internal or external fixation, with or without restricted open surgeries and bone grafting, or a combination of these techniques may be utilized. A joint-bridging external fixator is recommended when there is a significant contusion or soft-tissue injury to provide adequate support for the soft tissues to recover. The idea of spanning the knee joint was developed in the 1990s. The creation of this concept was sparked by proponents of indirect fracture reduction as well as biological fixation,

who claimed greater success rates [8]. Traction is used to reduce the fractures, which is then maintained with either internal or external fixation before a knee-spanning external fixator is placed. With the knee-spanning external fixator, the decrease of intraarticular fragments is maintained.

The Ilizarov method offers a solution to several issues that arise in the treatment of such fractures. It employs a closed reduction and fixation method that does not need significant soft-tissue removal [9-11]. The radiological and functional outcomes are enhanced when this Ilizarov external fixation is coupled with minimal internal fixation [12]. The researchers wanted to examine how Type VI tibial plateau fractures with significant soft tissue injury reacted to treatment with an Ilizarov spanning fixator across the knee joint.

## 2. METHODOLOGY

This prospective research, was conducted at Indus Medical College Tando Muhammad Khan Pakistan between the period from 2019 to 2020, comprised 14 participants. The regional ethics review board gave its approval to the research. The average age of the participants was 36 years old (range: 19–63 years old). There were eight males and six females among the patients. In every instance, the cause of injury was a car collision. In eight instances, there were open fractures and six cases had closed fractures with big blisters. Gustilo–Anderson type I fractures were found in two instances, type II in five, and type III in two. There were significant closed soft tissue damage in five of the closed fractures (mostly type I & II Tschern and Gotzen) [13].

**Table 1. Number of patients with grades of fractures with time to union**

Sr.no	Grade	No of patients	Time to union
1	I <sup>a</sup>	2	12
2	II <sup>a</sup>	5	14.6
3	III <sup>a</sup>	2	20
4	I <sup>b</sup>	2	13
5	II <sup>b</sup>	3	14

*a* Open fracture (Gustillo/Anderson).  
*b* Closed fractures (Tscherne/Goetzen).

(Table 1). All skeletally mature individuals with high-energy tibial plateau fractures (Schatzker VI), closed or open, were included. Antero-posterior (AP) X-rays were utilized to assess medial and lateral plateau involvement, as well as the degree of articular comminution, and lateral view x-rays were used to assess the amount of posterior condyle displacement and joint depression. The state of the soft tissues was critical in our preparations for the surgery. After a minimum of 12 months, all patients were reassessed. Patients with open fractures were operated on within six days after initial wound irrigation, debridement, and intravenous antibiotics, while patients with closed fractures were treated after a four-day delay (range 3–6 days) to enable soft tissue edema to decrease. The frame was extended onto the distal femur in instances with very complicated and unstable fractures, which kept the knee joint distracted.

**Operation techniques:** Under spinal anesthesia, the operation was carried out on a radiolucent operating table. The pieces were aligned with the use of a fracture table or simple manual manipulation. In both planes, the image intensifier showed the fracture reduction. The pieces were held in place using patella retaining forceps. Depressed articular fragments often need elevation (2 cases). An open reduction is needed when the articular fragments cannot be reduced. A tiny window was formed above the tibial cortex via a modest incision on the anterior medial part of the tibial metaphysis. A bone elevator was introduced into the opening, and pieces were raised beneath the image intensifier. There was no discussion of meniscal or ligament injury at the time. Inter-fragmentary compression was accomplished by running counter-opposed olive wires through the fragments after the condyles were reduced. Three wires with a divergence of at least 60° were typically required to stabilize the condylar and metaphyseal components. The wires were implanted at least 15 mm distant from the joint surface to prevent synovial contact and septic arthritis in the case of

a pin tract infection. The first 1.8 mm olive wire was inserted utilizing an image intensifier in a lateral to medial orientation immediately anterior to the head of the fibula at the subchondral area of the tibial plateau to create inter-fragmentary compression. All cables were run via secure zones. The first ring was secured to the first wire with two fixation bolts, which were then tensioned to provide compression between the articular fragments. Another olive wire was introduced from medial to lateral on the rings distal side, followed by a drop wire. This ring was then distally connected to another ring using four connecting rods. In terms of the condyles, the mechanical axis was meticulously repaired. As a distractor, the frame was extended onto the distal femur. The frame was secured between the quadriceps and the hamstring with two half pints. The tibial and femoral rings were connected using connecting rods. Gauze dipped in a povidone-iodine solution was used to treat the pin sites.

**Postoperative rehabilitation:** Open fractures were treated with daily dressings, delayed primary closure, or skin grafting, depending on the size of the wound. The only postoperative therapy needed was a daily pin tract dressing. Check radiographs were obtained the following day, and the fixator was modified the third day. Parenteral antibiotics were given up to the third day for closed fractures, and up to the third day for open and infected fractures until the infection was eradicated or the wound healed. Active and passive dorsiflexion exercises for the ankle were started on the second post-operative day. To avoid equinus deformity of the ankle, splinting was employed to maintain the foot in a neutral posture. Isometric quadriceps and hip lifting exercises were permitted. All patients were able to bear some weight at the end of one week, to the degree that their discomfort could be endured. Open fracture patients were examined once a week in the outpatient department until the wound healed. Check radiography was used to assess them every four weeks after that (as

patients with closed fractures). The femoral frame was removed on average 4.4 weeks following surgery, and knee ROM (range of motion) exercises were allowed.

The patients were all encouraged to bear part of their weight. After radiographic healing, frame dynamization was used to decrease pin bone stresses and provide weight-bearing pressures to the bone. It was believed that incomplete fracture healing had occurred when pain or minor radiographic changes were observed after frame dynamization. The structure was strengthened to allow for even more consolidation. The external fixator was removed after radiological evidence of union was obtained and the fracture was clinically united. Clinically, healing was defined as the ability to bear full weight while applying varus and valgus stress to the injured tibia without experiencing discomfort. As an outpatient procedure, all of the fixators were removed without anesthesia. A walking cast was worn for 3–4 weeks. Following the removal of the cast, physiotherapy was continued to improve the range of motion in the knee. Full weight-bearing was permitted with follow-up at three, six, and twelve months after radiographs were obtained without the use of a cast.

**Assessment:** All patients had a record of their clinical and subjective evaluations, degree of function, and radiological evaluations based on Honkonen and Jarvinens criteria [14].

Every patient was told to keep note of their symptoms, especially the frequency and severity. Edema, stiffness, weakness, limping, giving way, and crepitus were all symptoms. The severity was calculated by multiplying the patients assessed significance by the frequency of symptoms. The extension lag (in degrees), flexion range (in degrees), and thigh atrophy of all individuals were clinically assessed (in cm). On a scale of good to bad, these factors are evaluated. The final grade was the lowest in each of the four tests. As part of the functional assessment, the walk, stair climbing, crouching, leaping, and duck-walking were all assessed. The final score was the lowest of the five exams, ranging from excellent to poor. The radiographs were used to evaluate the plateau tilt, varus/valgus tilt, articular step off, condylar widening, and degeneration (relative narrowing of the joint). Antero-posterior and lateral planes were used to assess the radiographs. To assess plateau tilting, a line was drawn in the frontal plane between the lowest points of the weight-

bearing areas of the two condyles. The angle produced by that line and the long axis of the tibia was calculated. Local step-off was assessed when an unbroken portion of the articular surface was present. The usual position of the plateau was determined on a radiograph of the uninjured knee. The condylar widening was calculated using the width of the ipsilateral femoral condyles. Post-traumatic arthritis was characterized as a narrowing of the joint space as compared to the undamaged knee.

### 3. RESULTS

In our hospital, the average time between injury & application of the Ilizarov ring external fixator was 5.6 days (range 3.5–10 days). In all instances, the external fixator was tolerated for the duration of the therapy. Walking with partial weight-bearing was permitted after 5.5 days (range 4–7 days), while full weight-bearing was permitted after 17.4 weeks (15–25 weeks). The average length of stay in the hospital was 5.4 weeks (range: 2–18 weeks). All fractures healed after an average of 14.6 weeks of therapy with the frame (range 12–25 weeks). (Table 2). Within four months, all but two fractures had been repaired. Eleven patients needed further casting, whereas four did not require any other kind of support. One patients injury took more than six months to heal. Two patients were infected with pin track. All pin tract infections were treated with daily treatment without the need for wire removal. One patient had a varus union but was asymptomatic. Two patients needed split-thickness skin grafting and one required a muscle flap surgery for soft tissue covering.

A total of 14 patients recovered functional knee joint usage, with no discomfort or instability, and improved their quality of life. At a mean follow-up of 19.4 months, 14 patients attained flexion of 110° (range 70°–130°). The average knee flexion obtained in fractures treated with a knee distractor was 108° (range 70–130). 2/15 of the patients were able to bend their knees to 130°, and 6/15 were able to flex their knees to 120°. Three individuals were found to have a 5° loss of extension (range 0–8°). Only one patient had thigh atrophy of greater than 1 cm. Nine patients walked normally, while four had a slight limp. None of the patients utilized a cane or a walker. Squatting was normal in ten of the patients. The squatting limitation was noted in three individuals. 8/15 of the patients were able to ascend the stairs properly. Overall, there were seven outstanding results, seven acceptable

**Table 2. Details of 20 patients with their outcomes in Schatzker VI fractures**

Sr.no	Age	sex	Side	Soft tissue status	Fixation Femoral	Tibial	Full weight bearing	Follow-up month	Time to union	Range of motion	Outcome	Complication
1	25	M	R	Blister	No	12	15	24	14	120	Excellent	No
2	30	M	L	Open	4	13	16	18	15	120	Excellent	No
3	27	M	L	Open	4	13	16	30	24	70	Fair	Stiffness
4	35	F	L	Blister	6	16	20	18	16	100	Good	No
5	36	M	R	Open	4	15	17	18	15	120	Excellent	Pin tract infection
6	53	M	R	Blister	4	13	16	16	13	130	Excellent	Pin tract infection
8	48	M	L	Open	6	14	17	24	14	100	Good	No
9	39	F	L	Blister	4	12	22	16	16	120	Excellent	No
10	52	F	R	Open	4	16	15	15	13	100	Good	Varus deformity
11	47	F	R	Blister	6	14	17	20	14	130	Excellent	No
12	33	M	L	Open	6	18	16	18	16	100	Good	No
13	36	F	L	Open	No	12	17	18	24	100	Good	No
14	63	M	R	Blister	4	13	17	24	14	70	Fair	No

**Table 3.**

Sr. no	Subjective outcomes	Clinical outcomes	Functional outcomes	Radiological outcomes
1	Good	Excellent	Excellent	Excellent
2	Good	Excellent	Excellent	Excellent
3	Poor	Fair	Fair	Good
4	Fair	Good	Good	Fair
5	Good	Excellent	Good	Excellent
6	Excellent	Excellent	Excellent	Excellent
7	Fair	Good	Good	Fair
8	Fair	Good	Good	Fair
9	Good	Excellent	Excellent	Excellent
10	Good	Excellent	Excellent	Excellent
11	Fair	Fair	Good	Good
12	Good	Good	Good	Good
13	Excellent	Excellent	Excellent	Good
14	Fair	Good	Fair	Fair

results, and one mediocre outcome. (Table 3). Two patients had residual knee laxity, although none of them complained of functional knee instability. On AP radiographs, one patient had a 10° varus tilt. In two cases, lateral radiographs revealed a plateau tilt of less than 6°. Only one patient had an articular surface step of less than 4 mm. Tibial varus tilt was detected in two individuals when compared to the undamaged knee. The condylar widening was seen in seven individuals, with none exceeding 6 mm. There was no post-traumatic deterioration in any of the individuals. Six were excellent four were good, and four were fair on the radiological scale.

A total of 14 patients recovered functional knee joint usage, with no discomfort or instability, and improved their quality of life. At a mean follow-up of 19.4 months, 20 patients attained flexion of 110° (range 70°–130°). The average knee flexion obtained in fractures treated with a knee distractor (n = 13) was 108° (range 70°–130°). Three-fifths of the patients were able to bend their knees to 130°, and four-fifths were able to flex their knees to 120°. Three individuals were found to have a 5° loss of extension (range 0–8°). Only one patient had thigh atrophy of greater than 1 cm. Nine patients walked normally, while four had a slight limp. None of the patients utilized a cane or a walker. In 9 of the patients, squatting was normal. A squatting limitation was noted in three individuals. 8/15 of the patients were able to ascend the stairs properly. Overall, there were six outstanding results, five acceptable results, and two mediocre results (Table 3). Two patients had residual knee laxity, although none of them complained of functional knee instability.

There was no post-traumatic deterioration in any of the individuals. Six were outstanding, three were acceptable, and four were mediocre in terms of radiology.

#### 4. DISCUSSION

Choosing a treatment plan for the tibial plateau Schazker type-VI fractures with significant soft tissue damage have a poor long-term prognosis [15]. In the case of metaphysic-diaphyseal dissociation fractures, surgery is recommended [16]. In this research, 60% of the participants had open fractures and 40% had significant closed soft tissue injuries. Joint spanning circular fixation works effectively for soft tissue injuries, especially ligament damage (Ilizarov frame). Despite the considerable articular comminution in this instance, extending the fixator across the joint allowed the tissues to rest appropriately, resulting in a good functional outcome. When the articular congruity is preserved, the healing of the articular surface is considered to be adequate. Although closed techniques make it harder to accomplish anatomical reduction, intra-operative imaging helps in achieving congruent reduction. Instability of the knee after these fractures is a major cause of poor outcomes [17-19] Its disputed whether its caused by ligament laxity or bone malformation [20]. Although there is no agreement on whether or not it is necessary to treat concomitant ligament damage at the same time as the fracture, many people think it essential. The studys main emphasis was not on ligament damage. The Ilizarov circular fixation allowed for early mobility and weight-bearing in all of the patients, with no signs of instability.

Open reduction and internal fixation are not indicated in the presence of fracture blisters, extensive subcutaneous bleeding, and bruising. Infection rates are greater in 23–80% of patients with complex proximal tibial fractures, according to a review of the literature [21-24] in such fractures, Morandi et al. found that external fixation reduced the rate of complications [25] Percutaneous wires may be used to prevent further devitalization of the bone since the periosteal and endosteal blood supply are not affected. Olive wire secures the pieces to the condyle by acting as lag screws. They offer a reasonably stable joint surface and shield the components from vertical shear [26] Small tension wire helps to hold the small fragments [27] The lower limbs mechanical axis may be maintained and monitored by changing the frame. Wire migration may also be avoided by using external fixators to span the knee joint. Two of the patients required an open reduction with an elevation of the tibial plateau.

Early range of motion in such fractures has been extensively documented, but early loading has generally been avoided since the reduction in range of motion may be lost, resulting in depression of the joint surface or progressive deformity. On the other side, early weight-bearing may improve bone healing and muscle strength restoration, leading to a better functional outcome. The Ilizarov tibiofemoral frame allows for early weight-bearing. Soft callous development takes at least six weeks, according to this pattern. Early signs of healing as a consequence of early weight-bearing back up this theory [28] Multiple studies have shown that the average time to the union for complex tibial plateau fractures treated with circular wire external fixation is between 24 and 26 weeks [29-31] According to Kumar and Whittle, fracture union takes an average of 173 days, or 24.71 weeks (7.14–59.28 weeks). Behrens & Searls average union time was 186 days or 26.57 weeks. Tucker et al. found that all of the fractures healed without bone grafting, with union durations ranging from 12 to 47 weeks (mean 25.6 weeks). The patients in this series all recovered quicker than the published reports indicated.

Our research emphasizes the low morbidity associated with the Ilizarov method. There was no evidence of osteomyelitis or septic arthritis. This absence of infection and septic nonunion compares well to previously published research on similar complicated injuries [32,33]. Treatment

of tibial plateau fractures with the Ilizarov fixator showed an excellent to good functional outcome in 76–89% of patients [34,35]. 96.7 percent of the participants in this study had excellent to good function. Knee stiffness is a common symptom after tibial plateau fracture repair [36,37]. A flexion deficit of less than 100° and a 5° extension deficit indicate knee stiffness. The outcomes of this study compare well to those of ring fixators, which have demonstrated outstanding to good performance [36]. A limiting element was the small size of the research sample. Another difficulty was determining the articular inconsistency using CT images and subsequent CT scans.

## 5. CONCLUSION

In proximal tibia fractures, the Ilizarov procedure is a safe and effective approach with low morbidity. The Ilizarov procedure achieves early and definite fixation, allowing for early partial weight-bearing and high compliance. Removing the femoral ring, particularly after six weeks, has little effect on knee function and promotes fracture repair. Within four months of using Ilizarov, all of the patients had healed their fractures. The technique is suitable for the treatment of complex proximal tibia fractures when there is substantial comminution at the fracture site as well as soft tissue damage (Schatzker VI). This technique of treatment is highly suggested for such fractures.

## CONSENT

As per international standard or university standard, Participants' written consent has been collected and preserved by the author(s).

## ETHICAL APPROVAL

The regional ethics review board gave its approval to the research.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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