Ilizarov fixator versus plates and screws for treatment of high-energy tibial plateau fractures

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Abstract

Background: Bicondylar tibial plateau fractures stand as severe injuries that need surgical intervention. They are often linked to elevated complication rates as well as suboptimal clinical outcomes**.**

Objectives: To compare ilizarov external fixation and ORIF with plates and screws in treating bicondylar tibial plateau fractures, regarding alignment, stability, complications, and early weight-bearing.

Patients and methods: This prospective, randomized controlled trial involved 20 patients aged 20-60 with Schatzker types V and VI tibial plateau fractures. Patients were divided equally into two groups: the open reduction and internal fixation group and the ilizarov group. Outcomes such as limb alignment, joint stability, and complications were assessed, with statistical analysis using SPSS.

Results: 20 patients with good functional outcomes by knee society scoring system. Arthritis occurred in 4 cases (40%) in open reduction as well as internal fixation group and 5 patients (50%) in ilizarov group in open reduction as well as internal fixation group 6 cases (60%) did not develop infection, and four patients (40%) had deep infection while in ilizarov group four patients (40%) had no infection and six patients (60%) had pin track infection. In the open reduction as well as internal fixation group six patients (60%) had good union and four patients (40%) had delayed union while in ilizarov group nine patients (90%) had good union and only one patient (10%) had malunion.

Conclusion: ilizarov technique facilitated a shorter duration of definitive surgery, less soft tissue dissection, reduced hospitalization, sooner weight-bearing, accelerated healing, as well as decreased overall problems.

Keywords: Ilizarov Fixator; Plates and Screws; Tibial Plateau Fractures.
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Introduction

Tibia plateau fractures are a reasonably prevalent lower limb fracture type, constituting roughly 1% of all fractures **(Shadgan et al., 2015)**.

The anatomical relevance in these instances arises from the involvement of the articular surface. Additionally, these fractures often occur because of high-impact injuries **(Kugelman et al., 2017)**. The injury mechanism could induce a higher incidence of severe adverse events **(Lalić et al., 2014)**, resulting in serious soft tissue injuries **(Kugelman et al., 2017)**.

Bicondylar tibial plateau fractures (Schatzker types V and VI) **(Decker and Weaver, 2013)**. Generally, it occurs after high-energy trauma. Its mechanism could include motor vehicles, athletic activities, as well as falls from height. Generally, the predominant injury mechanism overall is pedestrian hit by motorized vehicles, accounting for 30% of cases **(Flandry and Hommel, 2011)**.

Tibial plateau fractures represent prevalent intra-articular injuries for which CT scans are regularly employed in pre-operative planning, which helps exclude other conditions **(Zhu et al., 2024)**.

Unhealthy soft tissue conditions with secondary surgical intervention may precipitate or at least elevate the risk of developing compartment syndrome **(Petersen and Zantop, 2007)**.

The ilizarov stands as a minimally invasive technique, which involves performing several small stab incisions for effective intervention, thus reducing soft tissue damage as well as blood loss **(Chan et al., 2010)**, in contrast to earlier techniques that produced much bigger scars **(Ruffolo et al., 2015)**.

This approach offers additional benefits for mechanics, as it ensures stability, allowing for precise alignment via potential changes during and post-surgery. The Ilizarov is significantly advantageous for patient mobility since it allows for early weight-bearing **(Colman et al., 2013)**, which represents a favorable prognostic factor for cases following the procedure.

The treatment objective is to achieve restoration of limb axis, joint stability, as well as precise intra-articular reduction while preventing further soft tissue injury **(Ariffin et al., 2011)**.

Open reduction and internal fixation (ORIF) are often utilized, employing a plate and screws. The dual incision technique is successful in achieving reduction and is far safer in comparison to extensile methods, exhibiting no substantial rise in infection rates **(Naja et al., 2022)**.

Additionally, external fixation can be employed along with minimal internal fixation, involving lag screws, offering articular fragment compression. Numerous studies indicate inconsistent rates of infections and sequelae when comparing ORIF versus external fixation **(Aurich et al., 2018)**. This work was aimed at comparing the findings of external fixation utilizing ilizarov ring external fixator versus open reduction and internal fixation utilizing plates and screws for treating tibial plateau fracture Schatzker types V and VI.

Patients and methods

Our team designed a prospective, randomized controlled clinical trial, including twenty cases, aged from 20 to 60, both sex, with tibial plateau closed, open fracture Gustilo I as well as Gustilo II, cases having bicondylar (Schatzker types V and VI) tibial plateau fractures, with intact neurovascular bundle and fitting for surgery at the Orthopedic Surgery Department at Badr Hospital, bank Ahly Hospital for 6 months. Approval was obtained from the research ethics committee and the faculty of Medicine Helwan University. Written informed consent was obtained from all

study participants after giving them suitable study-related - information.

Exclusion criteria were patients with tibial plateau open fracture Gustilo III, tibial plateau fractures schatzker (I, II, III, IV), medically unfit for surgery, pathological fractures and associated other lower limb fractures.

Patients were divided into two equal groups: Group I: underwent open reduction and internal fixation and Group II: underwent ilizarov.

All patients were subjected to complete history taking, general, local examination, laboratory investigations [complete blood count (CBC), coagulation profile, liver, renal functions, random blood glucose and virology] and radiological investigations [pre, post operative X-ray and preoperative computed tomography (CT)].

Methods and assessment of functional outcomes by knee scoring system. Hospital stays, arthritis, pin track, deep infection, union and malunion were assessed in all patients.

Techniques

A. Open reduction and internal fixation technique: Standard AO principles of exposure and fixation were used **(Society, 2006)**. A single anterior incision or combined medial and lateral incisions (at the discretion of the treating surgeon) with arthrotomy were used to perform an open reduction and lag-screw fixation of the articular surface. The menisci and cruciate ligaments were examined and identified, and soft-tissue injuries were repaired if possible. Typically, this involved screw and/or wire and/or suture fixation of avulsed cruciate ligaments with fragments of bone and repair of detached menisci with use of drill-holes in bone or suture anchors.

   Next, plates were applied in every knee medially and laterally to reestablish tibial alignment and buttress the articular repair. No locking plates were used in this series. Iliac crest bone-grafting was performed to support any impacted articular fragments after they were elevated and secured according to the preference of the surgeon. Standard wound closure over drains was performed.

   Open fractures were treated with immediate irrigation and debridement followed by immediate repair or temporary external fixation or splinting until the definitive procedure could be performed.

B. Ilizarov Operative Steps: Following pre-operative evaluation and assessment, the patients were positioned supine on the fracture table. Typically, spinal or epidural anesthesia was utilized.

The image intensefire (C - Arm) facilitated the reduction. Additionally, traction was used for reduction maintenance utilizing ligamentotaxis. The aim was to align the condyles relative to each other while reducing and stabilizing the tibial shaft underneath the reduced condyle.

In certain instances, an open minimal incision could facilitate reduction, utilizing reduction forceps. Additionally, a small window at the metaphyseal region could be created, thus pushing the articular surface from below, thereby reducing the depressed surfaces. Any identified defects were filled with a cancellous bone graft, preventing articular surface predepression.

Upon achieving reduction, the condyles were secured utilizing cancellous or cannulated screws measuring 4.5 mm, guided percutaneously under C-Arm imaging, thus stabilizing the condyles and restoring the articular surface. Occasionally, compression was applied by applying counter olive wire through the fragments to ensure optimal reduction.

Three to four wires must be positioned at least 14 mm from the joint line, which prevents capsular reflection, with an overall divergence of no less than 60 degrees.

Anatomic reduction to less than 2 mm is consistently verified after adequate initial reduction in both anteroposterior and lateral views. Minimal internal fixation was executed utilizing 6. 5 cannulated or cancellous partially threaded screws. We made a minor skin incision, verifying good mechanical axis alignment, after which the ilizarov frame was positioned.

We positioned the middle ring immediately distal to any fracture component of the shaft, while positioning the distal ring at a lower level and fixing it to a transfixion reference wire aligned parallel to the ankle joint, ensuring the tibial mechanical axis restoration.

We performed knee bridging in all examined cases due to the presence of high-energy unstable fractures characterized by significant comminution.

We applied a single complete ring and fixed it to the distal femur. This long frame across the knee facilitates enhanced stability as well as partial weight-bearing, ensuring the preservation of initial reduction precision throughout the first week.

Statistical analysis

Our team conducted a statistical analysis utilizing SPSS, statistical package version 22. Qualitative data were showcased as frequency and percentages. Quantitative data were showcased as Mean ± Standard deviation Median and Range. Differences with P below 0.05 were deemed statistically significant.

Results

According to age: Mean age of open reduction as well as internal fixation group indicated 32.1±9.10 ranged from 21 to 49 years. Mean age of ilizarov group was 36.9±4.04 ranged from 34 to 47 years. No significant variance was documented among the groups as regards age (P value > 0.05). (**Table .1)**

According to hospital stay All patients in open reduction as well as internal fixation group showed long hospital stay (> 7 days) while all patients in ilizarov group had short hospital stays (<7 days), the variance among both groups exhibited a statistical significance (P value 0.001). (**Table .1)**

According to Arthritis: Arthritis occurred in 4 cases (40%) in the open reduction as well as internal fixation group and 5 patients (50%) in ilizarov group, no significant variance was documented among both groups as regards the occurrence of arthritis (P value >0.05).

According to Infection: In the open reduction as well as internal fixation group 6 cases (60%) did not develop infection and four patients (40%) had a deep infection while in ilizarov group four patients (40%) had no infection and six patients (60%) had pin track infection, the variance among both groups showed a statistical significance (P value 0.006).

According to knee function: all patients in open reduction as well as internal fixation and ilizarov group were good (100%). No significant variance was documented among the groups as knee function (P value =1).

According to union: In open reduction as well as internal fixation group 6 cases (60%) had good union and four patients (40%) had delayed union while in ilizarov group nine patients (90%) had good union and only one patient (10%) had malunion, the variance among both groups exhibited no statistical significance (P value >0.05). Delayed union refers to the lack of radiographic evidence of healing or the instability of a fracture upon clinical

assessment between 4- and 6 months post-injury. Malunion signifies that a fracture has healed but in a suboptimal alignment.

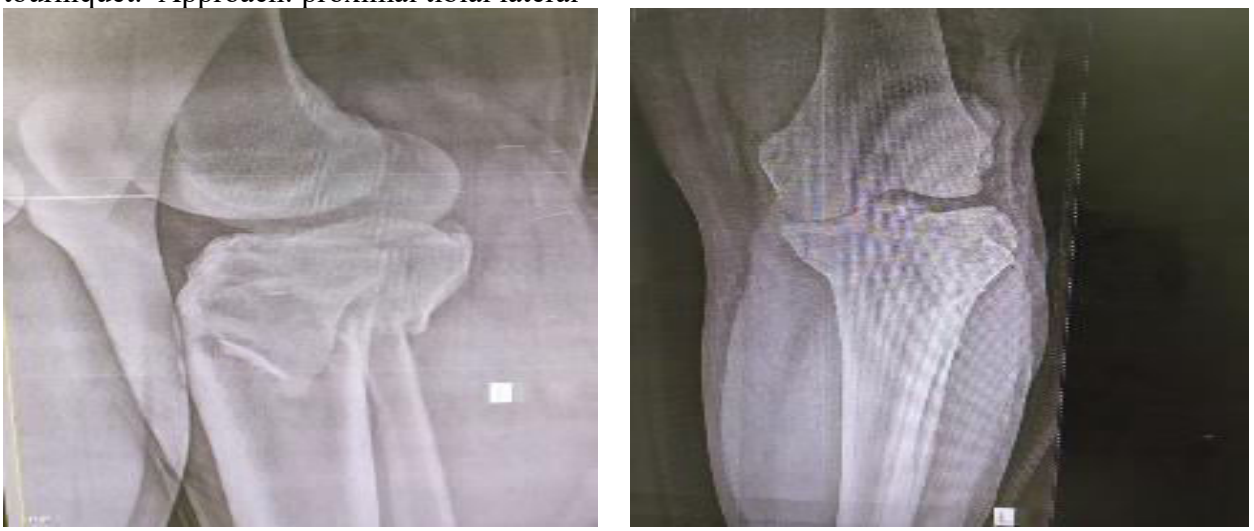
Table 1. Characteristics and outcomes of included patients

Studied variables	Open reduction and internal fixation group (N=10)	Ilizarov group (N=10)	P value
Age/year's Mean ±SD	32.1±9.10	36.9±4.04	0.109
Hospital stay percentage %			
Short	0	10 (100%)	0.001
Long	10 (100%)	0	
Arthritis percent %			0.653
Yes	4 (40%)	5 (50%)	
No	6(60%)	5(50%)	
Infection percent %			0.006
No	6(60%)	4 (40%)	
Pin track infection	0	6(60%)	
Deep infection	4 (40%)	0	
Knee function %			1
Poor (<60%)	0	0	
Fair (60-69)	0	0	
Good (70-85)	10 (100%)	10 (100%)	
Excellent (85-100)	0	0	
Union percent %			0.086
Good	6(60%)	9(90%)	
Delayed union	4 (40%)	0	
Malunion	0	1(10%)	

Data is presented as percentages% & Number.

Case (1): Male patient 23 years, driver, road traffic accident, has tibial plateau closed fracture type 6 on the left side according to Schatzker classification, fixed by double locked plates, intact peripheral neurovascular bundle. The radiographic images provided, A and B, depict a tibial plateau fracture in the left knee. Image A, the lateral view, shows a clear disruption of the tibial plateau's cortical outline, indicating a fracture. The fracture line is visible, and there may be an associated displacement or depression of the plateau. Meanwhile, image B, the posteroanterior view, demonstrates a break in the tibial plateau's continuity. The posteroanterior

view provides a better assessment of the fracture's alignment and any potential displacement or angulation. Surgical note, position: supine position with thigh tourniquet. Approach: proximal tibial lateral approach and posteromedial approach. Operation: open reduction and fixation by locked anatomical plates and screws. **(Fig.1).**

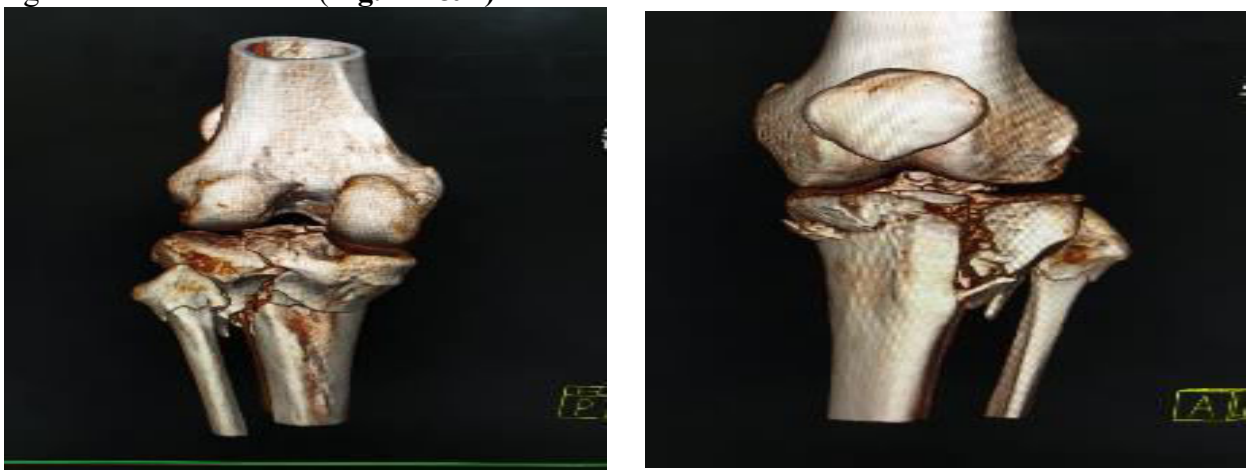


(A) **(B)**

Fig. 1. Admission x-ray, A) X-ray lateral view, B) X-ray posteroanterior view in knee

The 3D CT images show a comminuted tibial plateau fracture with multiple fragments, displacement, and a depressed fracture affecting the articular surface. The fracture line extends into the intercondylar notch, possibly compromising the cruciate ligaments, and a lateral tibial eminence fracture may indicate ACL avulsion. Joint effusion and soft tissue swelling are also present, indicating significant knee trauma. (**Fig. 2 A&B)**

The coronal view demonstrates a comminuted fracture with a large lateral fragment, while the sagittal view shows a depressed fracture of the lateral tibial plateau with impaction of the articular surface. The axial view provides a clear visualization of the fracture pattern, highlighting the extent of the injury and the potential for articular surface compromise. **(Fig.2 C&D&E)**



(A) **(B)**

(C) **(D)**

(E)

Fig.2. (A) 3D CT cuts, (B) 3D CT view, (C) CT cuts control view, (D) CT cut's sagittal view, (E) Ct axial view in knee

The anteroposterior x-ray view of the left knee demonstrates a high-energy tibial plateau fracture, characterized by a complex, comminuted pattern with significant displacement and articular surface impaction, indicating a potentially unstable injury. (**Fig.3)**

(A) **(B)**

Fig. 3. (**A) Anteroposterior X-ray view and (B) lateral X-ray view in knee**

The two sets of X-ray images, A and B, demonstrate the progressive healing of a tibial plateau fracture over 3 months. The initial images (A) show a comminuted fracture with significant displacement and articular surface impaction after 3 months, while the follow-up images (B) reveal significant bone healing and callus formation, indicating successful fracture consolidation after 6 months. (**Fig. 4)**

(A) **(B)**

Fig. 4. (A) 3month posteroanterior and lateral x ray view, (B) 6month Posteroanterior and lateral x ray view in knee

The patient developed a deep wound infection in the medial aspect, necessitating readmission for debridement and culture and sensitivity testing, which was performed without removal of the internal fixation device. (**Fig. 5).**

(A) **(B)**

(C)

Fig. 5. A) deep infection (saerosanenous discharge) in his medial wound, B) Knee extension (160 degree), C) knee flexion up to 90 degrees

The case underwent immobilization for six weeks. Partial weight bearing began after 14 weeks, full range of motion was restored after 4 months, functional outcome at the final follow-up showed favorable outcomes according to the knee scoring system. **(Fig.6)**

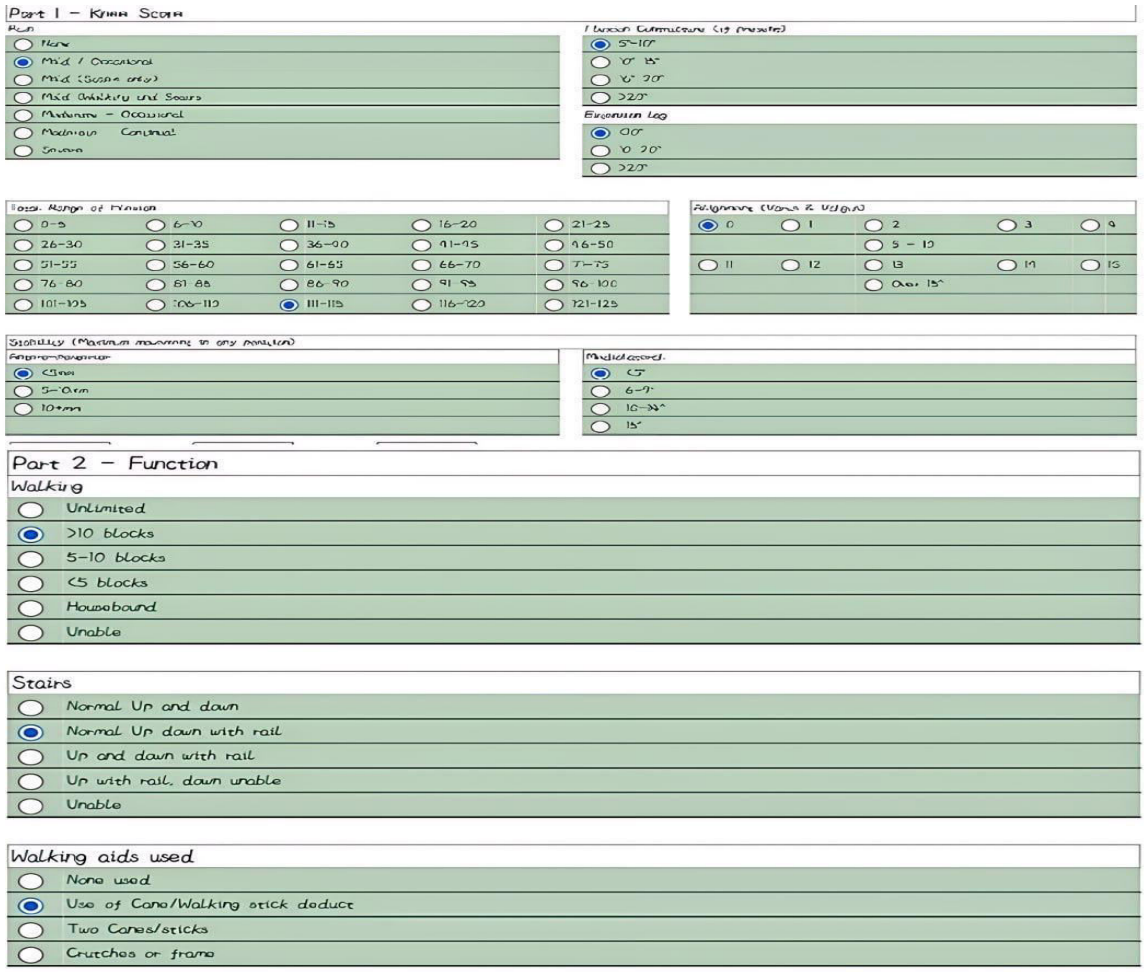
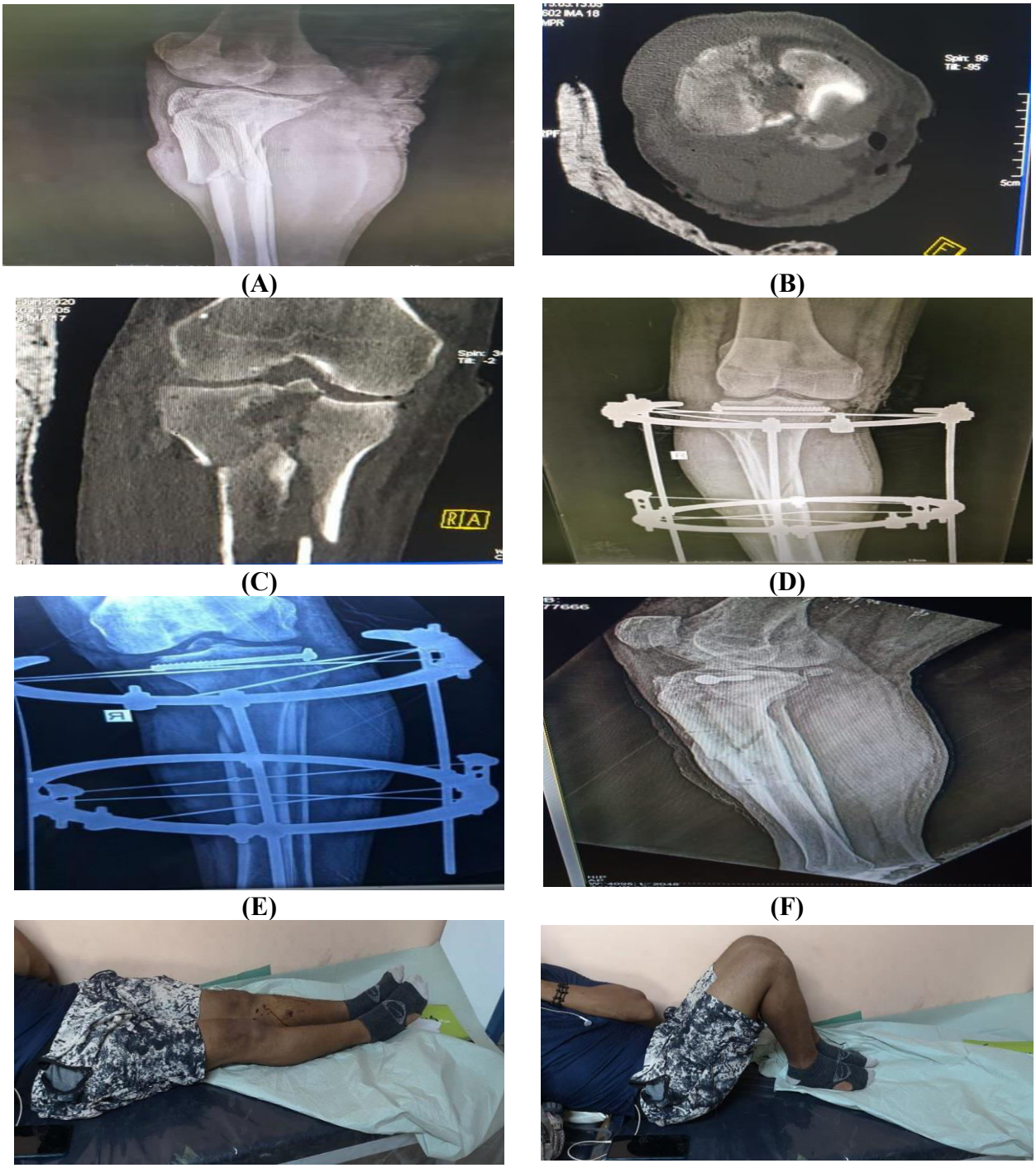


Fig.6. Knee society scoring system

Case 2: Male patient 47 years, old road traffic accident, driver, has closed tibial plateau fracture type 6 in the RT side according to Schatzker classification, Peripheral pulsation: intact, Neurology: intact, fixed by ilizarov fixator. Surgical note, position: supine position. Approach: small incisions for reduction. Operation: closed reduction and fixation by ilizarov external fixator. **(Fig.7).**



(A) **(B)** **(C)** **(D)** **(E)** **(F)** **(G)** **(H)**

Fig.7. (A) Admission X-Ray, (B, C) CT cuts, (D) post x ray, (E) three months follow up x ray, (F) eight months follow up x ray and (G, H) range of motion

This patient starts the range of motion immediately after operation, full range of motion was restored after 6 weeks, partial weight bearing started after 14 weeks, illizarov fixator removed in outpatient clinic after 8 months, functional outcome at final follow up was good (78) according to Knee scoring system. (**Fig.8)**

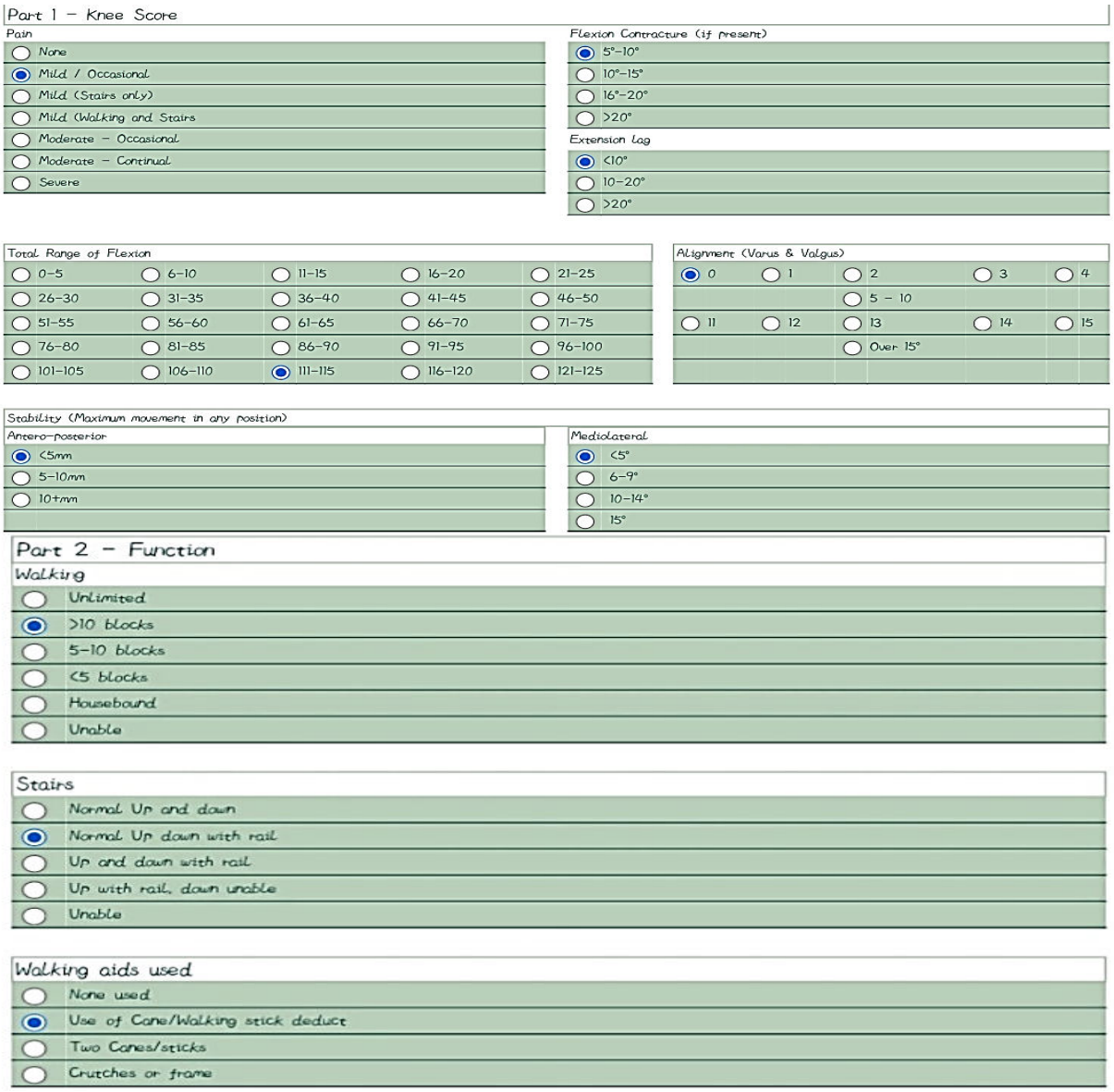


Fig. 8. Knee society scoring system

Discussion

Bicondylar tibial plateau fractures represent perilous injuries necessitating surgical intervention, often linked to elevated complication rates as we, as suboptimal clinical outcomes. Typically categorized as Schatzker type V/VI or AO/OTA 41C, these fractures are managed utilizing a range of internal and external fixation methods. Recent reports indicate that ORIF with dual plating achieves anatomical reduction along with a durable fixation, despite its association with a significant complication rate. This has resulted in the use of several therapeutic techniques, such as the ilizarov technique

and locking plates for fixation. Knee joint injuries involving bony and ligamentous structures lead to numerous complications, including infection, wound dehiscence, joint stiffness, joint instability, malunion, nonunion, as well as post-traumatic arthrosis. The incidence of these complications is influenced by the patient's age, bone quality, injury mechanism, concomitant ligamentous injuries, treatment approach, and postoperative rehabilitation **(Gálvez-Sirvent et al., 2022)**.

The research by Bidary et al.**(Pandey and Bidary, 2022)** demonstrated good to excellent AKSS outcomes in two-thirds of cases and good to excellent RRS grades in three-quarters of cases involving Schatzker type V and VI tibial plateau fractures managed utilizing closed reduction and ilizarov ring fixation, with or without percutaneous screw augmentation. All fractures healed with the return of a satisfactory range of motion

This research includes surgical intervention for 20 patients of bicondylar tibial plateau fractures by double plating or ilizarov according to postoperative complications and functional outcome according to knee scocity score.

In this randomized controlled study Mean age of open reduction as well as internal fixation group exhibited 32.1±9.10 ranged from 21 to 49 years. Mean age of ilizarov group was 36.9±4.04 ranged from 34 to 47 years. No significant variation was documented among the groups as regards age (P value > 0.05).

In our study, all patients of open reduction as well as internal fixation group exhibited long hospitalization while all patients in ilizarov group had short hospitalization; the variance among both groups showed a statistical significance (P =0.001)

In this study: Arthritis occurred in 4 cases (40%) in open reduction as well as internal fixation group while 5 cases (50%) in ilizarov group, no significant variation was documented among both groups as regards occurrence of arthritis (P value >0.05).

In this study: In open reduction as well as internal fixation group 6 cases (60%) developed no infection and four patients (40%) had deep infection while in ilizarov group four patients (40%) had no infection and six patients (60%) had pin track infection, the variance among both groups exhibited a statistical significance (P value 0.006).

In this study, in open reduction as well as internal fixation group 6 cases (60%) showed good union and four patients (40%) had delayed union while in ilizarov group nine patients (90%) had good union and only one patient (10%) had malunion, the variance among both groups showed no statistical significance (P value >0.05).

The ilizarov group show early operative intervention despite bad skin condition, faster recovery, short hospital stay, early range of motion less in deep infection, and so, better functional outcome but, On the other hand rate of malunion and pin tract infection is more with ilizarov group.

Debnath et al. **(Debnath et al., 2018)**, Watson et al. **(Watson et al., 2002)** address that the ilizarov approach has more favorable outcomes while managing complex tibial plateau fractures, with extensive comminution as well as compromised soft tissues. Therefore, it should be employed more often over other techniques. Pandey et al. **(Pandey and Bidary, 2022)**, Metcalfe et al. **(Metcalfe et al., 2015)**, and Brunner et al. **(Brunner et al., 2010)** address that the mode of fixation (ORIF or ilizarov ring fixator) shows no variation as regards the outcome.

Double plating group show more anatomical reduction and good, early union,

less arthritis, but on the other hand, more delayed operative intervention waiting of improvement of the soft tissue, higher rate of deep infection, long hospital stays, delayed ROM. The functional outcome represents the same in both techniques after 6 months of follow up according to knee society score.

Conclusion

Both approaches yielded satisfactory fracture reduction and clinical results. The ilizarov technique facilitated a shorter duration to definitive surgery, less soft tissue dissection, reduced hospitalization, sooner weight-bearing, accelerated healing, as well as decreased overall problems. The ilizarov approach offers an alternate treatment method to open reduction as well as locking plate fixation for closed bicondylar tibial plateau fractures. The key to achieving optimal results is to initiate early mobilization of the knee joint, thus achieving a full ROM.

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