

Application of hybrid external fixation by the “joystick method” in bicondylar tibial plateau fractures: Technical note

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ABSTRACT

BACKGROUND: This study aimed to present clinical outcomes in patients with tibial plateau fractures who were treated with hybrid external fixators and describe the details of our technique. Schanz screws were synchronously applied and used as a joystick for fracture reduction.

METHODS: The study population included 72 patients with bicondylar tibial plateau fractures classified as type 41-C2 according to the AO classification. Joint reduction was maintained using Schanz screws transmitted through tibial condyles as a joystick under fluoroscopy. The patients then underwent surgery with these Schanz screws and a hybrid external fixation system.

RESULTS: The median age of the patients was 39 (21–67) years, and the median follow-up time was 21 (12–35) months. The mean knee flexion and extension were 105° (80°–125°) and 0° (–5°–7°), respectively. The mean varus laxity and valgus laxity were 4.30° (2°–7°) and 3.10° (2°–5°), respectively. Four patients had leg shortness of 0.4–1.1 cm. The external fixators were removed between 8 and 16 weeks (mean = 11 weeks) postoperatively. The KSS scores at the end of 1 year were “excellent” for 48 patients, “good” for 19 patients, and “inadequate” for 5 patients.

CONCLUSION: With the synchronous application of the two Schanz screws of 6.5-mm thickness and the two-drill technique under fluoroscopic guidance, we obtained stable reductions over a short period. No patient experienced major complications, and this enabled early weight bearing and a return to daily living activities.

Keywords: Fracture complication; hybrid external fixation; tibial plateau fracture.

INTRODUCTION

The treatment of bicondylar tibial plateau fractures remains a complex and challenging issue for orthopedic surgeons despite numerous treatment alternatives.^[1] Bicondylar tibial plateau fractures constitute 2.9% of all tibial fractures.^[2] The goal of treatment is to provide joint-surface regularity, restore normal alignment, and achieve early joint movement.^[3,4]

Anatomical restoration of the joint surface is recommended, except for cases of tibial plateau fracture displaced less than

2 mm.^[5,6] Previous studies have reported excellent treatment outcomes following conservative treatment.^[7,8] External fixation, internal plate fixation, and arthroscopy-assisted techniques are surgical treatment alternatives. Despite the development of minimally invasive techniques and plate technology, open reduction and internal fixation represent the gold standard for treatment.^[9–12] However, owing to soft tissue compromise and its attendant complications, studies have reported superior or equivalent results using a hybrid external fixator.^[11] Herein, we aimed to present clinical outcomes in patients with tibial plateau fractures who were treated with

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hybrid external fixators and describe the details of our technique. Schanz screws were synchronously applied and used as a joystick for fracture reduction.

MATERIALS AND METHODS

Patients with bicondylar tibial plateau fractures who were treated with surgery between 2007 and 2013 at two hospitals were retrospectively evaluated using their electronic charts, which included patient backgrounds and radiological findings. Patients with pediatric fractures without growth plate closure, fractures with vessel and nerve injuries, open fractures, and instability requiring additional repair and reconstruction and patients who had posterior fragments with serious posterior slope changes were excluded; those who needed postoperative internal care unit follow-up visits, those who did not attend follow-up visits, and those with follow-up periods less than 12 months were also excluded. Patients with closed tibial plateau fractures were included in this study. Ultimately, the study included 72 patients (49 males and 23 females) with complete and simple articular bicondylar and metaphyseal multifragmentary tibial plateau fractures classified as type 41-C2 according to the AO classification. Two consultant orthopedic surgeons performed the operations at different hospitals. All patients provided written informed consent for the operations, and they were informed of the length of the rehabilitation period.

Joint reduction was maintained using Schanz screws transmitted through tibial condyles as a joystick under fluoroscopy. The patients then underwent surgery with these Schanz screws and a hybrid external fixation system. Full knee flexion, extension, and ambulation with partial weight bearing were allowed on the first postoperative day. All patients were discharged from the hospital on the second postoperative day. Two patients had additional extremity fractures (a contralateral distal diaphysis femur fracture and an ipsilateral distal diaphysis tibial fracture). One patient had post-polio sequelae on the operated side; however, these sequelae were not associated with our operation. The AO/OTA classification was used for fracture type classification.^[13] Fracture healing was evaluated using roentgenograms at the follow-up visits. The Knee Society Clinical Rating System (KSS) was used for clinical evaluation.^[14]

Surgical Technique

For fluoroscopy, the patients were placed in a supine position with slight elevators under their hips. For antibiotic prophylaxis, 1000 mg intravenous cefazolin was administered to patients preoperatively. Sedation and spinal anesthesia were administered to the patients preoperatively. A tourniquet was not used. Fluoroscopy was performed at opposite the surgical site. Flexion and 5/8" circular frame rings were selected for the proximal tibia. Distal monolateral external fixators were selected based on tibial lengths. These two modular apparatuses were combined.

Reduction was applied after the preparation procedure as follows: Schanz screws of 6.5-mm thickness and 50-mm groove lengths coated with 2-hydroxyapatite were fixed to two separate drills. Localization of the major fracture fragments was determined using fluoroscopy. After 1-cm skin incision and soft tissue dissection, two Schanz screws were placed 1 cm distally to the knee joint and vertical to the medial and lateral fracture fragments synchronously with two separate drills under fluoroscopic guidance by the same surgeon. After passing through the single cortex with the two Schanz screws medially and laterally, the Schanz screws were drilled forward to the end of the fracture fragments. After checking the movement of the fracture fragments for articular reduction using the same Schanz screws under fluoroscopy, the screws were used as joysticks, and reduction was performed. When the best anatomical reduction was obtained with fluoroscopy, the Schanz screws were passed through the far cortex synchronously. The aim of this technique is to allow sufficient reduction with minimal soft tissue dissection and prevent opening of the joint and fracture zones.

Block movement of the tibia in the antero-posterior and lateral directions was observed under fluoroscopy; after determining the appropriate joint regularity, the screws were fixed to the 5/8" rings. Previously selected monolateral external fixators were applied with three Schanz screws. A size 4 lengthening cube was applied to a suitable hole on the medial side of the proximal ring. The Schanz screws of 6.5-mm thickness and 50-mm groove lengths coated with 2-hydroxyapatite were fixed to the lower holes of the lengthening cube (Figs. 1a-c–2a-c). In this study, for each fragment, only one Schanz screw was inserted, and in order to prevent pulling out or loosening, hydroxyapatite screws were used.

After providing a final reduction of the system through distraction and compression, the system was completely stabilized. The screw and skin contact points were cleansed with hydrogen peroxide, and a sterile medical dressing was applied. Radiological evaluations were conducted using roentgenograms on the third week, sixth week, third month, sixth month, and first year postoperatively (Fig. 1c).

RESULTS

The median age of the 72 patients was 39 (21–67) years; this is the standard treatment of AO 41-C2 plateau fractures with our exclusion criteria. The median follow-up time was 21 (12–35) months. The etiologies of the fractures were traffic accidents for 45 patients (62.5%), falls from heights for 17 patients (23.6%), and falls for 10 patients (13.8%). The median operation duration was 47 (25–68) minutes. Blood transfusions were not required for any of the patients during the postoperative period. The mean knee flexion and extension were 105° (80°–125°) and 0° (–5°–7°), respectively. The mean varus laxity and valgus laxity were 4.30° (2°–7°) and 3.10° (2°–5°), respectively. Four patients had leg shortness of 0.4–1.1 cm (mean = 0.72 cm). After confirming full radi-

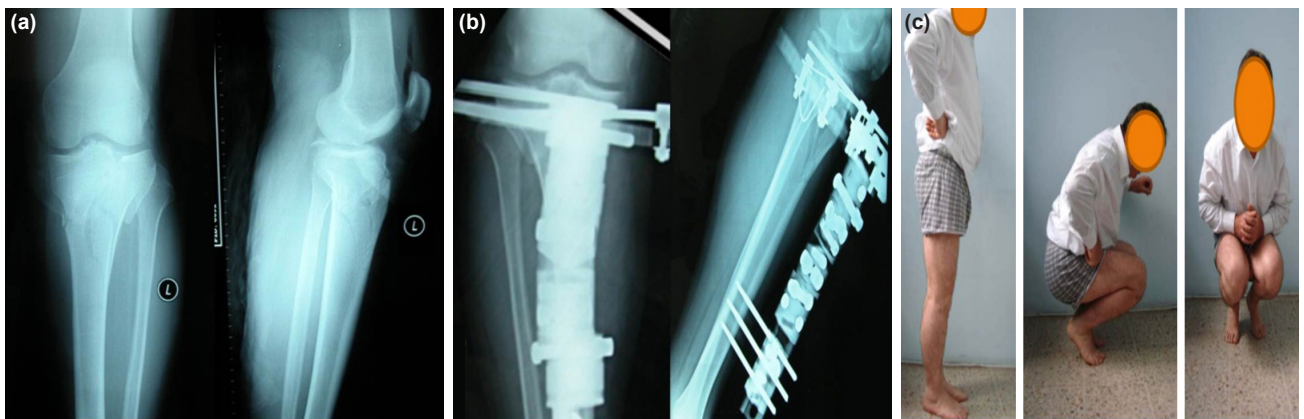


Figure 1. (a) Preoperative antero-posterior and lateral tibial roentgenogram of a 49-year-old male patient. The etiology of this bicondylar tibial plateau fracture was a traffic accident. (b) Postoperative roentgenograms of the patient. (c) Knee range of motion 6 months after treatment.

ological fracture healing, the external fixators were removed between 8 and 16 weeks (mean = 11 weeks) postoperatively. The KSS scores at the end of 1 year were "excellent" for 48 patients, "good" for 19 patients, and "inadequate" for 5 patients. Four patients with poor results underwent another operation, three underwent total knee arthroplasty, and one was treated with arthroscopic debridement and micro fracture. One of the patients with poor results was not accepted for the second operation, underwent physical examination, and was treated with platelet-rich plasma.

Full fracture healing was observed for all members of the study group. No patient experienced delayed union, malunion, or nonunion. Reflex sympathetic dystrophy was observed as

a complication in two patients who reported inadequate results (2.7%), and pin tract infection was observed as another complication in five patients; this complication was treated with local wound care and antibiotic therapy. Pin loosening was not observed in any patient. All patients showed good satisfaction, were mobilized at the first postoperative day, and were discharged from the hospital on the second postoperative day (Fig. 2a, b).

During the rehabilitation period, early active and passive range-of-motion exercises were recommended. All patients were allowed ambulation with partial weight bearing as tolerated with crutches for the first 6 weeks. Full weight bearing without crutches was recommended after the sixth week.

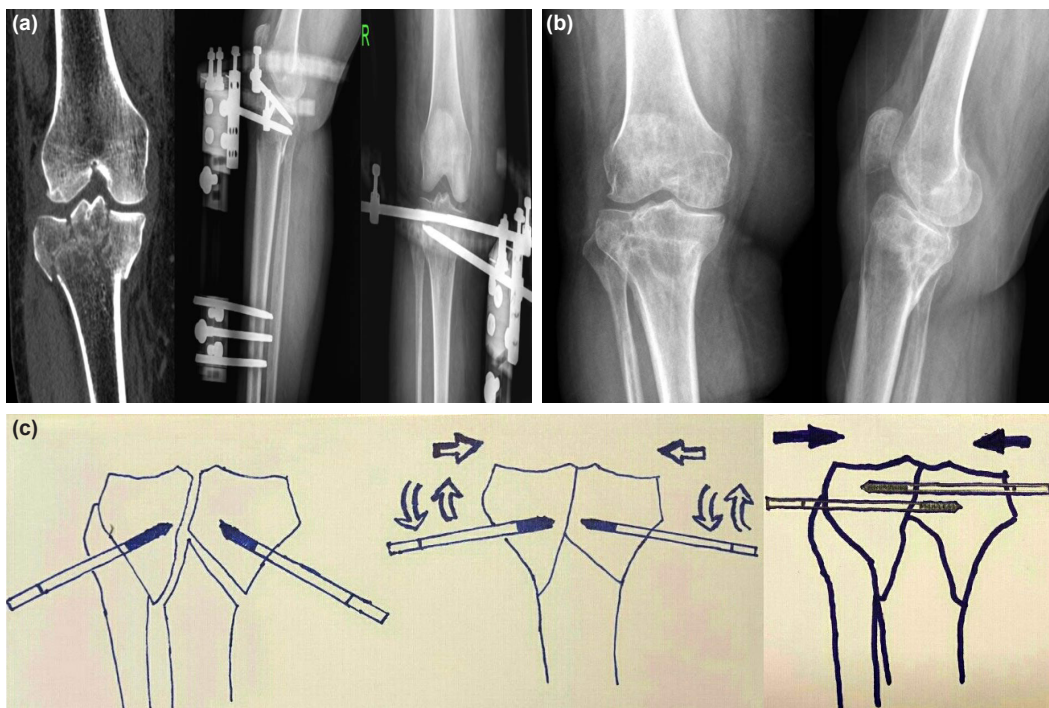


Figure 2. (a) Preoperative coronal view computed tomography of a 63-year-old female patient and postoperative antero-posterior and lateral images of the tibia. (b) The antero-posterior and lateral images of the patient's knee joint taken at 14 months postoperatively. (c) Illustrations of the surgical technique.

DISCUSSION

Most bicondylar tibial plateau fractures result from high-energy traumas.^[15,16] The goal of treatment is to achieve a pain-free and stable knee joint with a functional range of motion.^[4,12,17] Despite excellent results reported using conservative treatment, prominent displacement and ligament injuries causing instability are the major indications for surgery.^[4,14,17] Circular external fixators such as the Ilizarov apparatus and computer-assisted frames have been used for more than 30 years as a treatment for tibial plateau fractures; the problems with the Ilizarov apparatus are prolonged hospital stay and long surgery duration.^[18] Computer-assisted frames have a higher equipment cost difference compared with that of other external fixation systems.^[19]

Previous studies have documented skin necrosis as a result of soft-tissue trauma and open reduction with internal fixation as a risk factor for an increased infection rate.^[12,16–18] Mallik et al. reported similar results but showed a decreased complication rate using a hybrid external fixator compared with that for open reduction and plate osteosynthesis.^[10] In our study, five patients experienced pin tract infection, and two patients experienced reflex sympathetic dystrophy; the bearing was not correctly applied by these two patients.

In another study, the use of a hybrid external fixator was compared with closed reduction and conservative treatment methods. The authors of that study warned against the risk of joint-surface derangement because of early movement among patients in which a hybrid external fixator was applied with K-wires.^[19] This disadvantage was not observed when the external fixator with Schanz screws was applied and a stable fixation was maintained. In the current study, joint-surface derangement was not observed in any of the patients, as confirmed by fluoroscopy, despite the recommendation of early active and passive range-of-motion exercises as well as partial weight bearing.

Krupp et al. compared the hybrid external fixators with plate screw fixation for Schatzker type V/VI plateau fractures. He reported that the union time, stiffness, and overall complications decreased with the plate screw technique. They depicted that hybrid fixation may be reserved for spanning the joint before definitive open surgery.^[20]

In our study, we used hybrid external fixators or open reduction and plate screw fixators only when posterior fragments existed. Reduction of posterior fragments with close manner can increase the risk of vessel or nerve injury; thus, our patients were treated with open reduction and internal plate screw fixation.

Stable fixation and early motion are indispensable in this type of intra-articular fracture.^[13] Fixation systems enabling early motion provide better cartilage nutrition, which might pre-

vent osteoarthritis development. In our study, we allowed a safe range of motion and partial weight bearing without yielding joint-surface derangement.

Tourniquet use during open reduction and internal fixation of lower extremity fractures might lead to complications such as deep vein thrombosis, muscle necrosis, or nerve injury.^[21,22] Tourniquet-related complications, such as ischemia and deep vein thrombosis, were not observed in our study, owing to the absence of a tourniquet requirement. No patient required blood transfusion due to the minimally invasive nature of the operation. The mean operation duration was 47 (25–86) minutes.

One of the limitations of this study was its retrospective design. The limited number of patients and the relatively brief duration of the follow-up period are additional limitations. The lack of an objective evaluation of joint step formation using magnetic resonance imaging or computed tomography was a disadvantage of this study.

Conclusions

With the synchronous application of the two Schanz screws of 6.5-mm thickness and the two-drill technique under fluoroscopic guidance, we obtained stable reductions over a short period. No patient experienced major complications, which enabled early weight bearing and a return to daily living activities.

Hybrid external fixation using Schanz screws via the “joystick method” should be considered as a rapid, easy-to-apply method with low morbidity and successful results for treating bicondylar tibial plateau fractures. However, long-term randomized prospective studies are required in the future.

Conflict of interest: None declared.

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ORJİNAL ÇALIŞMA - ÖZET

Tibia plato kırıklarında "joystik yöntemi" ile hibrid eksternal fiksator uygulaması: Teknik not

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AMAÇ: Tibia plato kırıklarında, hibrid eksternal fiksator uyguladığımız hastalarımızın klinik sonuçlarını sunmayı ve uyguladığımız joystik tekniğinin detaylarını sunmayı amaçladık. Tekniğimizde Shanz çivileri eşzamanlı joystik olarak kullanılmakta ve redüksiyon sağlanmaktadır.

GEREÇ VE YÖNTEM: Çalışmamız AO sınıflama sistemine göre tip 41-C2 olan 72 bikondiler tibia plato kırıklı hastayı içermektedir. Eklem redüksiyonu, kondillerden geçen shanz çivilerinin floroskopi eşliğinde eş zamanlı yapılması ilksine dayanmaktadır. Daha sonra hibrid eksternal fiksator sistemine adapte edilmektedir.

BULGULAR: Ortalama hasta yaşı 39 (21-67) ve ortalama takip süresi 21 (12-35) ay idi. ortalama diz fleksiyon ve ekstansiyon değerleri sırası ile 105 (80-125) ve 0 (-5-7) derecedi, ortalama varus ve valgus laksitesi 4.3 (2-7) ve 3.1 (2-5) derecedi. Dört hastada 0.4-1.1 cm arasında değişen ekstremite kısalığı mevcuttu. Knee Society Clinical Rating System (KSS) skoru birinci yıl sonunda 48 hasta için mükemmel ve 19 hasta için iyiydi. Beş hasta için yetersizdi.

TARTIŞMA: 6.5 mm kalınlığında Shanz çivileri ile eş zamanlı yapılan tekniğimizle kısa cerrahi sürede hastanın kırığı floroskopi eşliğinde redükte edilmekte ve fiksasyonu sağlanmaktadır. Hiçbir hastada majör komplikasyon gelişmedi, erken yük verme ve hareket ile günlük yaşama çabuk döndüler.

Anahtar sözcükler: Hibrid eksternal fiksasyon; kırık komplikasyonu; tibia plato kırığı.

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