Original Article

Comparative study of single lateral locked plating versus double plating in type C bicondylar tibial plateau fractures

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Abstract

Background: Bicondylar tibial plateau fractures are complex injuries and treatment is challenging. Ideal method is still controversial with risk of unsatisfactory results if not treated properly. Many different techniques of internal and external fixation are used. This study compares the clinical results in single locked plating versus dual plating (DP) using two incision approaches. Our hypothesis was that DP leads to less collapse and change in alignment at final followup compared with single plating.

Materials and Methods: 61 cases of Type C tibial plateau fractures operated between January 2007 and June 2011 were included in this prospective study. All cases were operated either by single lateral locked plate by anterolateral approach or double plating through double incision. All cases were followed for a minimum of 24 months radiologically and clinically. The statistical analysis was performed using software SPSS 10.0 to analyze the data.

Results: Twenty nine patients in a single lateral locked plate and 32 patients in a double plating group were followed for minimum 2 years. All fractures healed, however there was a significant incidence of malalignment in the single lateral plating group. Though there was a significant increase in soft tissue issues with the double plating group; however, there was only 3.12% incidence of deep infection. There was no significant difference in Hospital for special surgery score at 2 years followup.

Conclusion: Double plating through two incisions resulted in a better limb alignment and joint reduction with an acceptable soft tissue complication rate.

Key words: Tibial plateau fracture, bicondylar fracture, locking plate
MeSH terms: Tibial fracture, bone plates, knee

Introduction

Bicondylar tibial plateau fractures are complex injuries necessitating a restoration of both articular congruity as well as axial alignment of lower extremity and frequently associated with soft tissue injury.[1] The treatment of bicondylar fractures is challenging and ideal method still controversial with risk of unsatisfactory results if not treated properly.[2,3] Many different techniques of internal and external fixation are used to treat these fractures.[2-8] When both condyles are involved, buttressing or fixation of both the medial and the lateral cortices with dual plates has been indicated to prevent medial collapse and subsequent varus deformity.[1] Horwitz *et al*.[9] found that double plating with either a dual buttress construct or a lateral buttress/medial antiglide construct has significantly higher stability than an isolated lateral buttress plate. The lateral buttress/medial antiglide technique is favored by the Osteosynthesefragen (AO)/Association for the Study of Internal Fixation.[10] However, osteosynthesis is dependent on the balance between achieving rigid fixation and preservation of the local biological environment and this balance may be compromised with dual plating (DP).[1] With the advent of locked plates and angle stable constructs specifically designed for the proximal tibia and minimally invasive techniques like less invasive stabilizing system (LISS) made it possible to achieve fixation of some displaced bicondylar injuries without directly plating the medial side.[1] However, biomechanical study demonstrate that the dual plate fixation allows less subsidence in this bicondylar tibial plateau cadaveric model when compared with isolated, locked

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lateral plates. Clinical studies also have shown similar results with isolated lateral locked plating.[1,11] Barei *et al*.[12] using a computed tomography (CT) scan study demonstrated the presence of the posteromedial fragment in nearly 33% of bicondylar fractures. Historically, medial or posteromedial plating through a single midline incision resulted in high wound complication rates and deep sepsis, prompting an exploration of alternative techniques of stabilization, including a two incision surgical approach.[2-8,11,13] The two-incision approach theoretically enables the surgeon to sufficiently visualize and both reduce tibial condyles and apply dual plates if desired, avoiding the soft tissue complications associated with anterior midline exposures.[3,14]

The purpose of this study was to compare the clinical results in single locked plating (SP) versus DP using two-incision approaches. Our hypothesis was that DP led to less collapse and change in alignment at followup compared with single plating.

Materials and Methods

61 cases of type C tibial plateau fractures operated between January 2007 and June 2011 were included in this prospective study. During the study, the procedures followed were in accordance with the Helsinki declaration of 1975, as revised in 2000 and informed consent was obtained from all patients for use of data and imaging for scientific purpose. This was a surgeon specific cohort study with SP operated by one group of surgeons and DP operated by another group. All surgeons participated had at least 3 years of experience postresidency. Inclusion criteria were (1) All type 41 C tibial plateau fractures as per Orthopedic Trauma Association classification.[15] (2) Patients operated within 3 weeks of injury. Exclusion criteria were (1) Gustilo type 3 open fractures[16] (2) Vascular injury (3) Patients with head injury or abdominal and thoracic trauma requiring operative intervention.

On admission, patients were put in an above knee plaster slab where in surgery was performed on the same day or next day. Whenever surgical delay beyond 48 h was anticipated calcaneal skeletal traction was applied over a Bohler Braun splint. Preoperative biplanar radiographs and CT scans were obtained in all patients. Soft tissue injury was graded with Tscherne grading[17] and in case of severe soft tissue injury a joint spanning external fixator was used taking care that tibial pins were at least 10−15 cm beyond the distal most fracture line. In patients with SP, an anterolateral exposure through an L shaped incision and a 3.5 periarticular proximal tibial locking plate (Zimmer, US) was inserted beneath the tibialis anterior muscle. In DP constructs, the medial condyle was first fixed through a posteromedial approach[18] using a reconstruction plate/3.5 DCP/Distal end radius plates (Phoenix Surgical, New Delhi, India) in a buttress mode and laterally by the 3.5 periarticular proximal tibial locking plate (Zimmer, US). All the proximal screws in the lateral locking plate in both DP and SP groups were applied in the locking mode. The articular reduction on medial side was obtained under fluoroscopy guidance. Laterally reduction was visualized through sub meniscal arthrotomy and was confirmed under fluroscope, provisionally reduction was held with pointed clamp and K-wires and later fixed with lag screws and plate. The position of the plate was adjusted under fluoroscopic control. Iliac crest bone grafting was used to support the metaphyseal void after elevation articular fragment whenever required.

Postoperatively patients were put in a long knee brace for 2 weeks. Isometric quadriceps exercises and knee range of motion was encouraged from 3rd day depending on patient tolerance to pain. Patients did nonweight bearing crutch walking for at least 12 weeks with partial weight bearing after that and full weight bearing allowed only after radiological healing of the fracture. Followup visits were done at 6 week's interval until fracture healing was seen and later at 3 months till 1-year and every 6 months until at least 2 years. At followup visits, they were evaluated clinically and radiologically for fracture healing and alignment [Figure 1A and 1B]. Bony union was defined radiolographically when at least three cortices united. Nonunion was defined as no evidence of healing after 6 months. The axis of the tibia was defined according to Paley *et al*.[19] Malreduction was defined as an intraarticular step-off of 2 mm or greater, or a malalignment in the frontal or sagittal plane of >5° according to Paley *et al*.[19] An increase of 5° malalignment or in articular depression of 2 mm compared with the first postoperative radiograph was defined as secondary loss of reduction.[19] Hospital for Special Surgery scoring was done at 12, 18 and 24 months. Complications during the followup period were recorded.

The statistical analysis was performed using software SPSS 10.0 (Chicago, Illinois, USA) to analyze the data: A Yate's correction of Fisher's exact test was used to compare between the two groups and *P* values below 0.05 were considered as statistically significant.

Results

Seventy five patients (39 SP and 36 DP) were operated during the study period. However, we lost 14 patients (10 SP and 4 DP) during followup who could not be traced. Both groups were similar in relation to the age distribution, mechanism of injury, fracture pattern and soft tissue injury [Table 1]. In surgical details, there was a statistically significant increase in surgical time with the DP group; however, the mean reduction time between the two groups

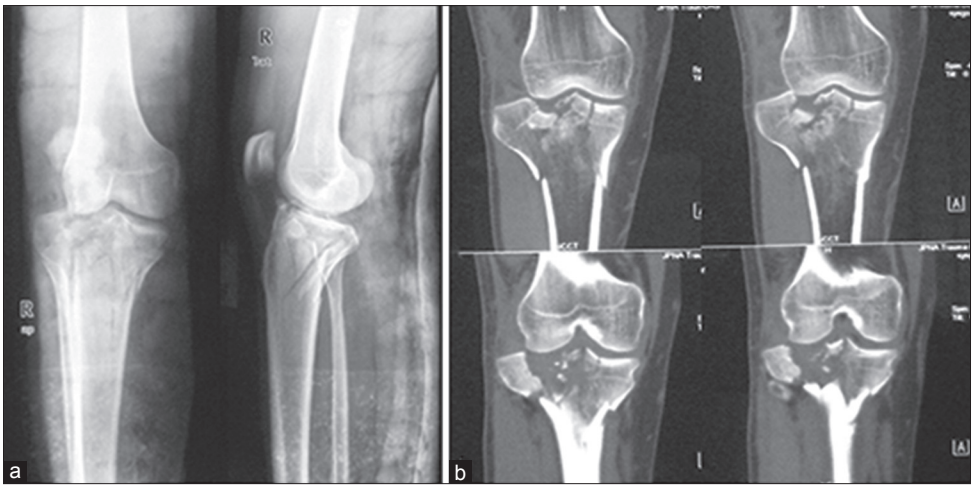

Figure 1A: (a) X-rays of knee joints anteroposterior and lateral views (b) Computed tomography scan coronal images showing Type C bicondylar tibial plateau fractures

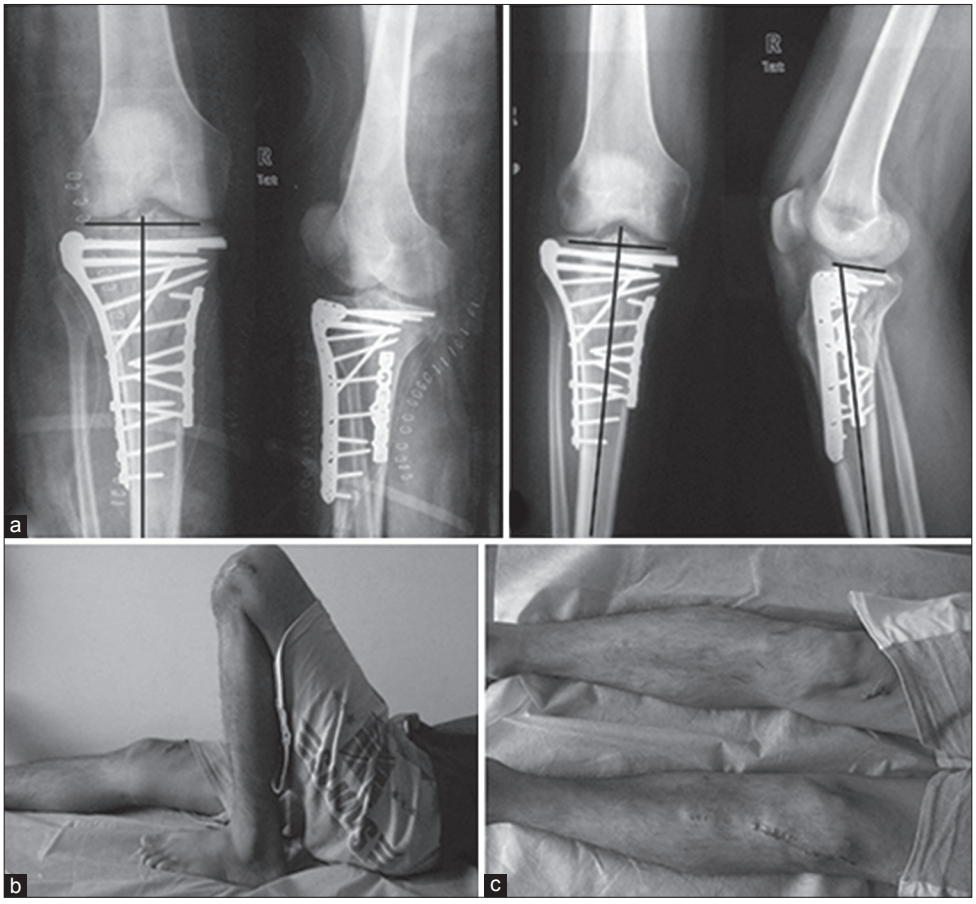

Figure 1B: X-rays of knee joints anteroposterior and lateral views (a) immediate postoperative (b) 2 years followup showing double plating and tibial plateau at right angle to tibial axis. (c) Clinical photographs at 2 years followup showing range of motion

was not significant [Table 2]. Decision to bone graft was at the discretion of the operating surgeon and was an intraoperative decision with 44 (70%) patients receiving bone grafting. Immediate postoperatively there was no difference in between the groups regarding the postoperative malalignment and reduction [Table 3]. All cases united by 5 months and we had no cases with nonunion or implant failure. We had statistically significant secondary loss of alignment into varus in SP group in five patients [Figure 2]. There were four cases with superficial infection in lateral wound of DP group. No organism was isolated on aerobic and anaerobic culture and healed subsequently however

prolonged antibiotic therapy of 2 weeks was considered in these patients. There was one incidence of deep infection in a double plating group, where in *Staphylococcus aureus* was isolated. Extensive irrigation and wound lavage with antibiotic beads was given. Irrigation and lavage were again repeated at 2 weeks with removal of beads and later received prolonged antibiotics for 6 weeks after which the infection resolved. However at followup, this patient had restricted range of motion (Flexion 0-50°). A total of 24 (75%) patients in a double plating group regained full flexion (135°) and full extension (0°) with a good alignment and no pain and instability, whereas in a single plating group, this was seen in 18 (62%) patients at followup.

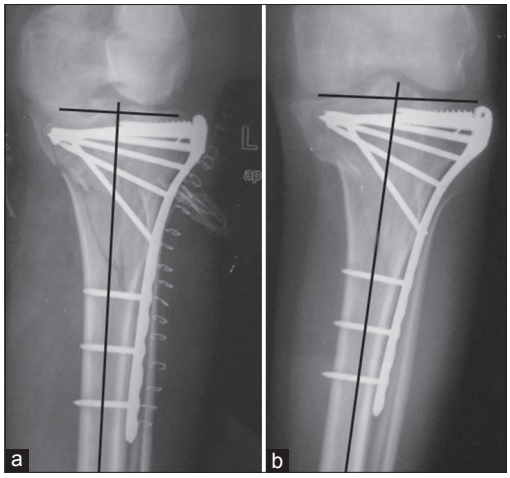

Figure 2: X-ray of knee joint with leg bones anteroposterior view (a) immediate postoperative (b) 2 years followup showing single locking plate and change in axis at followup

Table 1: Clinical details of patients

Details	SP	DP	*P*
Patients in study	29	32	0.439
Male:Female	20:9	21:11	0.76
Age (years)	41 (range 19-67)	37 (range 21-56)	0.134
Mode of injury	RTA: 22	RTA: 24	0.24
	Fall: 7	Fall: 8	
Isolated fracture	20	21	0.38
Multiple fracture	9	11	0.67
Ipsilateral lower limb fracture	5	3	0.12
Fracture type (OTA)			
C1	10	11	0.75
C2	11	13	
C3	8	8	
Soft tissue injury for closed fracture			
Tscherne C0	10	16	0.086
Tscherne C1	7	5	
Tscherne C2	4	4	
Tscherne C3	2	3	
Soft tissue injury for open fractures			
Gustilo grade 1	5	4	0.61
Gustilo grade 2	1	0	
Medical co-morbidities			
Diabetes mellitus	6	4	0.43
Hypertension	4	5	

RTA=Road traffic accident, OTA=Orthopaedic trauma association

Discussion

This study was performed to compare the medial collapse and change in alignment in a bicondylar tibial plateau fracture stabilized either by an SP or DP. The construct selected must be applied in a fashion that minimizes complications, allows early knee range of motion and is durable enough to maintain the articular reduction throughout bony healing.[11] Our hypothesis that collapse and change in alignment is less after DP is accepted by this study.

Our average followup was 24 months and hence it is not possible based on this study to look into long term results. However, since fracture union occurred in both methods by around 4 months and as fracture remodeling is complete by 2 years we believe that the change in alignment due to the

Table 2: Surgical details of patients

Surgical details	SP	DP	*P*
Average time to surgery	8.5 days (range 6-21 days)	9 days (range 4-18 days)	0.58
Mean operation time (min)	112 (range 65-210)	134 (range 72-270)	0.03
Mean reduction time (min)	42 (range 15-96)	40 (range 25-78)	0.23
Mean image intensifier time (min)	4.1 (range 2-9.2)	4.7 (range 2.6-8.2)	0.26
Plate size used	5 hole	5 hole	
	7 hole	7 hole	
	9 hole	9 hole	
	11 hole	11 hole	
		Distal radius buttress plate	
Bone grafting	20	24	0.54

SP=Single plating, DP=Double plating

Table 3: Complications

Complications	SP (*n*=29)	DP (*n*=32)	*P*
Postoperative malalignment	3	2	0.46
Postoperative malreduction	3	3	0.71
Radiographic healing time (weeks)	14 (range, 10-20)	15.2 (12-20)	0.48
Loss of reduction	2	1	0.092
Loss of alignment	5	0	
Infection (%)			
Superficial	2 (6.69)	4 (12.5)	0.034
Deep	0	1 (3.12)	
Implant irritation	4	5	0.57
Knee range of motion	128° (range, 90-135)	124° (range, 50-135°)	0.33
HSS score at 18 months followup	79 (range, 68-88)	80 (range, 52-90)	0.451

HSS=Hospital for special surgery, SP=Single plating, DP=Double plating

procedure per say should not occur after that. Theoretically, there is a possibility of further change in alignment into varus due to progression of osteoarthritis that we have not looked into.

With a single incision required for lateral SP fixation, we did have a statistically significant differences in surgical time were found between the two groups. However, there was no difference in time required for reduction of fracture. The advantages of SP/LISS fixation include unilateral fixation and application of self-drilling and self-tapping screws, may theoretically shorten the operating time. However, reduction of fragments and restoration of alignment for bicondylar fractures through a single lateral incision are technically demanding and this may offset any decreases in operating time during fracture fixation.[3]

Soft tissue complications are a major concern in the treatment of bicondylar tibial plateau fractures with plates. Papers reporting the results of DP through a single extensile incision have shown the incidence of deep wound infection of 23–88%.[4,13] With the two incision DP technique, the incidence drops to 4.7–8.4%.[13,14] With LISS fixation, it is reported to range from 0% to 22%.[20-22] Jiang *et al*.[3] had a deep infection rate was 4.7% in DP group and 7.3% in LISS group. Zhang *et al*.[23] had a deep infection rate of 3.8% which was comparable to 3.12% seen in our study. In addition in our study, we had 4 cases (12.5%) with superficial infection wherein no organism was isolated and healed by prolonged antibiotics for 2 weeks. It was also seen that two of these cases were Tscherne C III, and two were Gustilo Grade 2 open and all were operated within 5 days of injury. Thus, gentle handling of the soft tissues with a nontraumatic technique and a staged surgery allowing the compromised soft tissue to heal before definitive fixation can help reduce soft tissue complications and infection rate. It is better to manage initially with transcalcaneal skeletal traction or an external fixator for 5–14 days during the first stage, which also helps to restore leg alignment and maintain soft tissue length, while facilitating healing and preventing further soft tissue damage.

Malalignment was common, with immediate postoperative malalignment and delayed loss of alignment occurring in 10.34 and 17.24% respectively in SP group and 6.25% and 0% in a double plating group in our study [Table 4]. Malalignment has also been reported at a significant rate in other series [Table 5]. The criteria used for malalignment have varied, and the quality of radiographs and the reliability of the measurement techniques make it hard to compare the different series.[22] Varus collapse was the most common pattern for change of alignment. In osteoporotic bone or in severe comminution, the fixation may not be strong enough to provide stability to the proximal tibia, because the best quality bone is close to the subchondral area.[22] Barei *et al*.[12] in CT based study demonstrated the occurrence of a posteromedial fragment in approximately one third of AO/Orthopedic Trauma Association C-type bicondylar tibial plateau fractures. This is clinically relevant because laterally applied fixed angle plate/screw devices that are used to treat bicondylar tibial plateau fractures may not effectively neutralize this osteoarticular fragment and require alternate or supplemental exposures and/or fixation strategies.[11,12] Gosling *et al*.[24] evaluated the LISS used alone to treat 69 bicondylar tibial plateau fractures and reported that 16 patients had a significant malreduction and 9 patients had a loss of reduction these three had posteomedial fragment not caught by locking screw. There is the inability of locking screws with predetermined trajectories relative to the plate to engage the posteromedial fragment. The 3.5 mm periarticular Zimmer locking plate used in our series had four diverging screw proximally giving a raft like effect to support the subchondral bone and to catch the posteromedial fragment. However achieving articular reduction and alignment is demanding and is not consistently reproduced[3] and we still had 4 of our seven cases with mal-alignment with a separate posteromedial

Table 4: Cases with postoperative malalignment or loss of alignment

Case	Fracture type	Plating method	Postoperative malalignment		Loss of alignment	
			Coronal	Sagittal	Coronal	Sagittal
1	C2	SP	8° varus			
2	C3	SP	8° varus			
3	C3	SP	11° varus	6° hyper extension	Further 8° varus	
4	C3	DP	6° varus			
5	C2	DP	7° varus			
6	C3	SP			6° varus	
7	C3	SP			9° varus	8° hyper extension
8	C2	SP			8° varus	
9	C3	SP			8° varus	

SP=Single plating, DP=Double plating

Table 5: Review of literature for loss of alignment in SP and DP group

Study	Postoperative mal-alignment %	Loss of alignment %
Single plate		
Gosling *et al*., 2005[24]	23	14
Phisitkul *et al*., 2007[22]	22	8
Jiang *et al*., 2008[3]	14.6	4.7
Our study	10.34	17.24
Double plate		
Zhang *et al*., 2012[23] (double buttress)	0	4.87
Zhang *et al*., 2012[23] (locking Lat and med buttress)	0	2.63
Jiang, 2008[3]	2.3	2.3
Our study	6.25	0

SP=Single plating, DP=Double plating

fragment. Bio-mechanical and cadaveric studies have also shown that dual-plate fixation allows less subsidence in this bicondylar tibial plateau cadaveric model when compared with isolated, locked lateral plates.[1,11] Zhang *et al*.[23] compared double buttress plating construct with another construct of combination of lateral locked plate and medial buttress showed no significant difference two groups in the rate of secondary loss of reduction and alignment.

Our study has several limitations. The number of patients in our study is a weakness as no prior power analysis was made. At the time of surgery in DP group, two plates of different makes were used which we do not recommend. The final followup evaluation was only 24 months after the surgery. It is possible that, with time, many of these patients may have posttraumatic arthritic change develop in the knee, especially since the articular reduction and alignment restoration were imperfect in some of them.

Although laterally applied fixed angle implants have gained popularity for the treatment of type C bicondylar tibial plateau fractures, the results of this study demonstrate that DP through two incisions resulted in a better limb alignment and joint reduction with an acceptable soft tissue complication rate.

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