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ORIGINAL PAPER

Tibial plateau fractures: functional outcome and incidence of osteoarthritis in 125 cases

Nikolaos Manidakis · Anis Dosani · Rozalia Dimitriou · Dirk Stengel · Stuart Matthews · Peter Giannoudis

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Introduction

Tibial plateau fractures occur due to a combination of axial loading and varus/valgus applied forces leading to articular depression, malalignment and an increased risk of post-traumatic osteoarthritis (OA) [14, 19].

When treating intra-articular fractures, the goal is to obtain a stable joint permitting early range of motion for cartilage nourishment and preservation [19]. Various treatment modalities have been used over the years, with mixed results. These include traction [3] or closed treatment with cast bracing [9, 16]. Surgical procedures including circular frames [1, 2, 18], percutaneous screw fixation [17], open reduction/internal fixation (ORIF) [1, 5, 6, 10, 28] and arthroplasty have also been advocated. More recent techniques such as the use of fixed angle devices [12, 20], arthroscopically-assisted reduction [8], calcium based cement augmentation [26, 29] and the use of novel grafting methods to address articular depression [4], constantly gain popularity amongst orthopaedic surgeons. Protection from weight bearing and length of immobilisation receive varied emphasis among authors [2, 11, 27].

Despite anatomical joint reconstruction, development of osteoarthritis may still occur secondary to the initial articular cartilage and meniscal injury [14, 21]. In young patients this could be detrimental as it can lead to total knee replacement (TKR) at an early age. In addition, these fractures may have significant socio-economic influence, mainly due to time taken off work. In order to assess the effect of these injuries on functional outcome and development of OA, we retrospectively reviewed a series of tibial plateau fractures treated in our institution.

N. Manidakis (✉) · A. Dosani · R. Dimitriou · S. Matthews · P. Giannoudis
Academic Department of Trauma and Orthopaedic Surgery,
School of Medicine, University of Leeds,
Leeds, UK
e-mail: nimanidakis@hotmail.com

D. Stengel
Department of Trauma & Orthopaedics,
Center for Clinical Research,
Unfallkrankenhaus Berlin and University of Greifswald,
Berlin, Germany

Patients and methods

From January 2003 to December 2006, 156 consecutive adult patients with tibial plateau fractures were identified. Thirty-one patients were either lost to follow-up or died and were excluded from the final analysis. Thus, 125 patients (73 males, 52 females, mean age 52 [range 18–94 years]) form the basis of this report. The patient profiles are summarised in Table 1.

Besides radiographs, all patients had computed tomography scans (CT) for accurate fracture evaluation and classification according to Schatzker et al. [25]. Seven open fractures were graded according to Gustilo et al. [13], and treated with wound debridement and lavage. Soft tissue coverage was required in five cases and was provided with vascularised muscle flaps and split skin grafts either immediately or within 48 hours. Skeletal stabilisation was achieved using implants suitable to the personality of the fracture and the surgeon's preference. Postoperatively all patients received a third generation cephalosporin for 24 hours. Patients who had an open wound received antibiotic treatment for a minimum of five days.

One hundred and one patients were treated surgically and 24 conservatively. In general, fractures were stabilised by either ORIF or percutaneous screw fixation with or without

Table 1 Patient demographics

Variable	*n* (*N*=125)
Gender	
Male	73
Female	52
Mean age, years (range)	52 (18–94)
Mean ISS (range)	10 (6–52)
Associated injuries	29
Injury mechanism	
Road traffic accident	86
Fall	37
Gun shot	2
Schatzker type	
I	31
II	42
III	21
IV	9
V	6
VI	16
Open fractures	
Grade I	1
Grade IIIa	3
Grade IIIb	3

an external fixator device. The mean time to operation was 72 hours (range three hours to ten days). A midline incision was used for ORIF of bicondylar fractures whereas a lateral or medial incision was used for unicondylar fractures. Depressed fractures were elevated and stabilised by inserting a tightly fitted bone block from the iliac crest.

In cases associated with marginal split fragments, the joint surface was supported with a buttress plate. This method was used in 69 of the 101 surgically treated patients. Where appropriate, double buttress plating was used for condylar support (three patients). In cases where percutaneous screw fixation was required, the fracture was reduced by means of ligamentotaxis and stabilised using 6.5-mm cannulated screws. Fifteen patients were treated with percutaneous screws as the sole method of fixation, whereas in 12 cases a hybrid frame complemented the reconstruction. In two cases a combination of internal and external fixation was used. Iliac crest bone grafting was required in 63 cases for reconstruction purposes.

Nonoperative treatment was selected based on patients' physiological state and fracture characteristics. The majority were type I, II and III fractures, compared to only two type IV and no type V and VI fractures. The period of cast brace immobilisation in patients treated nonoperatively ranged from six to ten weeks. Full weight bearing was discouraged for eight weeks.

After discharge, all patients were followed-up regularly in the trauma clinic for clinical and radiological assessment. At final follow-up, all radiographs were reviewed by the senior author for any degree of joint depression, loss of alignment and the presence of OA. Radiological features of OA included the presence of joint space narrowing, articular margin osteophytes, as well as subchondral cysts and sclerosis. Mean follow-up was 20 months (range 12–70).

Union was defined as evidence of bone healing by direct or indirect means in at least two radiographic planes and a full painless weight bearing joint. Functional assessment was performed using the American Knee Society score (AKSS) [15]. Pain was assessed using a visual analogue score (VAS) ranging from 0 to 100. Because of the rather small sample size, VAS ratings were grouped into five categories (I: 0–20, II: 21–40, III: 41–60, IV: 61–80, V: 81–100). All patients were also asked to report any changes in their employment status as a result of the injury.

Statistical analysis was conducted in an exploratory fashion. Data are presented as means, medians, and proportions according to the underlying distribution. Where suitable, 95% confidence intervals (CI) were calculated as a measure of precision. We also evaluated whether the presence and degree of fracture severity and later OA predicted functional results, using logistic and ordered logistic regression analysis. We employed STATA 10.0 software for all analyses.

Results

The average time to union was 13 weeks (range 8–36). No significant differences ($p>0.05$) regarding time to union were noted in cases treated both operatively and non-operatively. Out of all the included cases, excellent joint reduction and alignment were achieved initially in 94 cases (75.2%, 95% CI 66.7–82.4%), but was reduced to 71 (56.8%, 95% CI 47.6–65.6%) at final follow-up. Malalignment included 12 (9.6%) cases of residual varus (ten with 8 degrees and two with 15 degrees) and 11 (8.8%) cases of residual valgus deformity (up to 10 degrees). Five patients developed leg-length discrepancy (two with 2.0 cm, two with 1.5 cm and one with 1.0 cm).

Nineteen patients (15.2%, 95% CI 9.4–22.7%) suffered superficial infection. All were successfully treated with local wound care and antibiotics. Deep infection was observed in 12 patients (9.6%, 95% CI 5.1–16.2%). Two of them had been treated with external fixation and developed deep sepsis within two weeks of the operation and were managed with surgical debridement. Nine patients were diagnosed with deep sepsis at six months following surgery and required metalwork removal. One patient developed deep infection one year after surgery and required sinus excision and metalwork removal.

Four patients who had been treated with a fine wire fixator developed septic arthritis and required joint irrigation. Fourteen patients were subjected to a second operative procedure following union (six patients had metalwork removal, one underwent metalwork removal and application of a hemicallotasis device and seven patients underwent arthroscopy). Nine patients underwent a third procedure (five had metalwork removal, one had application of a hemicallotasis device for malunion correction and three underwent debridement and curettage of the discharging sinus).

Two patients developed compartment syndrome. This was treated by fasciotomies and subsequent split skin grafting. Seven patients had deep venous thrombosis (DVT) and three of them developed pulmonary embolism (PE). They required admission to the intensive care unit and anticoagulation therapy. Postoperatively, one patient developed a foot drop but fully recovered 12 months later without permanent damage.

At final follow-up, evidence of radiological OA was present in 33 of 125 cases (26.4%, 95% CI 18.9–35.0%). Out of the 23 patients that were subjected to loss of reduction, 18 were found to have radiological changes. Ten patients had arthritic changes in all compartments while three had medial and 20 had lateral compartment OA.

Patient-centred outcomes are summarised in Table 2. The severity of injury predicted the later onset of OA (odds ratio [OR] 1.97, 95% CI 1.49–2.59, $p<0.0001$); it also predicted later pain severity (OR 1.28, 95% CI 1.03–1.57, $p=0.023$). Likewise, pain severity was associated with the degree of OA (OR 2.32, 95% CI 1.10–4.87, $p=0.026$), although this association was not linear (Fig. 1).

Five patients (one with Schatzker type VI, three with type III and one with type II) required TKR, because of significant collapse and OA. In four patients this was required two years after the injury and in one case after five years. One required revision TKR due to infection.

The AKSS was good in 86 cases (68.8%, 95% CI 59.9–76.8%), fair in 30 cases (24.0%, 95% CI 16.8–32.5%) and poor in nine (7.2%, 95% CI 3.3–13.2%). Three of the cases with poor results were seen in patients who developed deep

Table 2 Patient outcomes

Variable	Schatzker type (*n*)					
	I	II	III	IV	V	VI
Mean age, years (range)	54 (18–94)	50 (20–84)	49 (23–83)	53 (21–90)	57 (21–90)	44 (19–86)
Gender						
Male	21	26	10	4	2	10
Female	10	16	11	5	4	6
Surgical treatment	15	39	18	7	6	16
Mean time to union, weeks (range)	8 (5–16)	8 (6–16)	10 (6–24)	12 (10–20)	18 (12–24)	21 (12–36)
American Knee Society score						
Good	21	33	12	6	3	11
Fair	9	8	7	2	1	3
Poor	1	1	2	1	2	2
Patients without OA	27	37	17	5	1	5
VAS, patients without OA						
I	17	25	10	3	1	2
II	2	2	2	1		1
III		1	2			
IV	1		2			
V	7	9	1	1		2
Patients with OA	4	5	4	4	5	11
VAS, patients with OA						
I	4		1	1	2	4
II		2	1	1	1	2
III		1				
IV			1			
V		2	1	2	2	5
Additional procedures	0	4	2	4	5	5
Unable to return to previous work	0	4	4	3	1	4

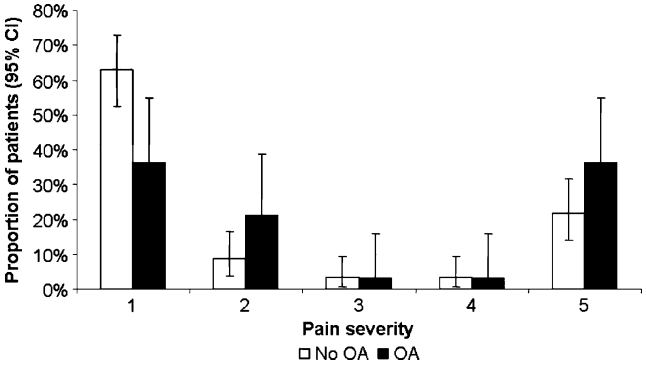

Fig. 1 Association between the presence of osteoarthritis (OA) and pain severity

infections. The other six had multiple injuries that significantly affected outcome.

Discussion

The management of tibial plateau fractures is a challenging task for the surgeon, as they are often associated with a number of complications [22]. Problems of classification have previously been addressed in the literature [25]; however, evaluation criteria and optimal management remain controversial.

Twenty-four patients in our series were treated non-operatively, most often due to their poor medical condition. They were treated with cast bracing and early active motion. The majority of patients were treated operatively. CT scans were obtained for detailed assessment of articular damage and to aid in preoperative planning. Sixty-nine cases were treated with a buttress plate. Arthrotomy, elevation of depressed fragments, ORIF and bone grafting was used in all patients with depressed or displaced articular fragments to achieve anatomical joint reconstruction. It has been well documented that instability due to articular incongruity predisposes to uneven loading and early OA [19, 24]. It is not surprising therefore that minimally displaced tibial plateau fractures had the best results when open or closed methods of reduction were used, followed by early range of knee motion [7, 9, 24].

External fixators, combined with minimal ORIF offer high mechanical properties; however, pin track problems are not to be underestimated, since the device has to remain in situ until fracture union [2, 11]. External fixation was used in 12 cases by means of the AO hybrid frame combined with cannulated screws. Although the number of patients in this group is small, our findings suggest that in cases of fragmentation and extensive soft tissue damage, techniques of indirect reduction and percutaneous screw fixation can effectively stabilise fractures. According to our data, fracture severity and adequacy of reduction were closely related to functional outcome.

We achieved excellent joint reduction in 94 cases at the time of initial surgery but this number was reduced to 71 at the final visit. Loss of reduction was directly proportional to Schatzker type, which was worse in the bicondylar group (50%).

Complex tibial plateau fractures are associated with nonunion and malunion, as a result of comminution, unstable fixation, failure to bone graft, infection or combination of these factors. The rate of nonunion in this series was 1.6% which is comparable to other studies [10, 18]. Nonunion is rare in low energy fractures reflecting the good blood supply of the proximal tibial cancellous bone.

There was 9.6% incidence of residual varus deformity. Gaudinez et al. reported 19% of varus deformity in his series of 18 complex (types V and VI) fractures [11]. Residual varus resulted in 6/22 (27.3%) of our types V and VI. We had ten patients with 10 degrees or less of varus, who did not require any further intervention; however, two

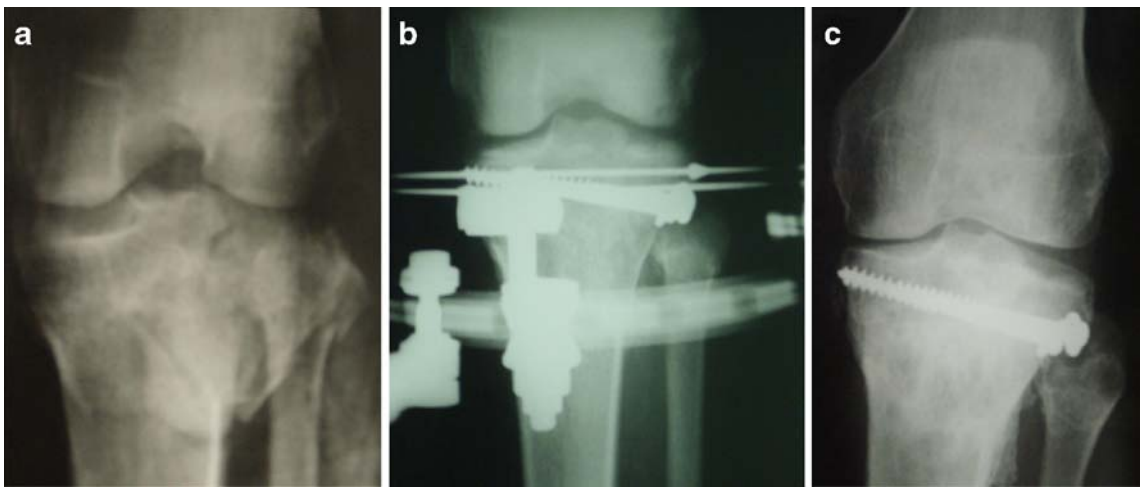

Fig. 2 **a** Preoperative anteroposterior (AP) radiograph of a Schatzker type VI fracture. **b** Early postoperative AP radiograph following combination of internal and external fixation. **c** AP radiograph at final visit after removal of the circular frame. Moderate osteoarthritis (OA) changes seen

with 15 degrees underwent reconstruction by hemicallotasis. Eleven of our patients developed <10º of valgus and did not require further surgery.

The most devastating complication associated with the management of tibial plateau fractures is infection. Its incidence can be decreased by careful surgical timing and soft tissue handling. Indirect reduction techniques and minimally invasive surgery also decrease the likelihood of further devascularisation. In our series the incidence of superficial and deep infection was 15.2% and 9.6%, respectively. Four patients (3.9%) with bicondylar fractures, developed septic arthritis and were treated by metalwork removal and wash out. Infection rates range between 0 and 87.5% in the literature [1, 5, 6, 10, 17, 18, 28].

Compartment syndrome is often associated with high energy trauma. Two (1.6%) patients developed this complication. A recent series of 41 bicondylar fractures reported 9.76% incidence of compartment syndrome [5]. Ebraheim et al. reported a 23% incidence in their series of 117 fractures treated with ORIF [10].

Patients with tibial plateau fractures are at high risk of thromboembolic complications. Despite anticoagulation measures and early mobilisation, seven (5.6%) patients developed DVT and three (2.4%) PE; however, all recovered satisfactorily. Other studies have reported rates ranging between 1.7% and 20% [5, 10, 27].

The incidence of OA following tibial plateau fractures varies in the literature. Numerous investigators have demonstrated that articular incongruity and joint instability can lead to early post-traumatic joint degeneration [7, 14, 19]. Decoster et al. reported radiological changes in 32% of patients with an average follow-up of ten years [9]. Jensen et al. reported 20% moderate to severe changes in the follow-up of 106 cases [16]. Rasmussen reported 17% overall incidence of posttraumatic OA in his series of 260 fractures; however, its incidence in the bicondylar group was 42% [24]. Rademakers et al. reported a 31% incidence of arthrosis with symptomatic degeneration, which was more severe in cases where malalignment of more than 5 degrees was present [23]. Gaudinez et al. reported 83% of radiological changes in one year follow-up of patients with comminuted tibial plateau fractures [11]. In this series, radiological evidence of OA was present in 33 out of 125 cases (26.4%), while the incidence of radiological OA in complex tibial plateau fractures (types V and VI) was 58% (Fig. 2). A recent multicentre, prospective, randomised clinical trial comparing internal fixation with circular fixators for bicondylar plateau fractures reported 28.5% vs 37.8% incidence of radiographic OA between the groups at one year [1].

Different scoring systems have been used to evaluate functional outcome of tibial plateau fractures. We used the AKSS which is graded between 0 and 100. A score of <60 was graded as poor, 60–70 as fair, 70–85 as good and 85–100 as excellent. The outcome was good in 86 cases (69%), fair in 30 (24%) and poor in nine (7%). Others have reported good/excellent scores in 65–89% of subjects [9, 10, 16, 17]. Poorer outcomes can be expected following complex fractures; however, Ali reported 80% of satisfactory functional and radiological outcomes using fine wire fixators for these injuries [2].

Our results are comparable with other published studies. The introduction of minimally invasive techniques and limited dissection where appropriate, can provide stable fracture configurations and promote reliable bone healing, while preserving the soft tissue envelope. Only five patients (4%) in our series underwent TKR, but we anticipate that with time the number may increase. The best results occurred in patients with unicondylar fractures associated with isolated split fragments. The worst results were noted in patients with bicondylar fractures, associated with diaphyseal-metaphyseal dissociation reflecting the severity of the injury. This study illustrates that tibial plateau fractures continue to remain an important cause of morbidity. Treatment goals should include a congruent articular reduction, adequate knee stability, anatomical limb alignment and avoidance of complications. Functional outcome and limitation of post-traumatic OA is directly dependent on achieving these targets.

Finally, we are aware that this study has a number of limitations including a follow-up period of less than ten years, use of different methods of fracture fixation, it is not a single surgeon's series and it is of retrospective nature. Despite these limitations, we believe that it provides useful information with regard to the intermediate functional outcome following these injuries. Although pain severity was associated with the degree of OA, this association was not linear. This can be valuable in informing patients about the outcome that can be expected.

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