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Arthroscopy-assisted operative management of tibial plateau fractures

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Abstract This retrospective review evaluated the results of arthroscopy-assisted surgery for tibial plateau fractures in 45 patients with closed tibial plateau fractures. The fracture involved articular depression in 27 patients in whom lifting and bone grafting with autogenous corticocancellous iliac bone graft was required. In 23 patients there were also meniscal lesions, which were treated by partial resection in 16 and repaired in 7. Internal fixation was performed using screws in 36 knees and plate in 10 knees. Radiological results were evaluated according to the Resnic-Niwoyama criteria; mean follow-up was 36 months (range 14–72). There was no intraoperative complication in the series, but postoperatively there were one infection and one loss of correction. Results were satisfactory in 89% of cases, according the Rasmussen criteria. Arthroscopy is thus an excellent and minimally invasive method for assessment and treatment of tibial plateau fractures. The advantages are complete and anatomical reduction in the fractured articular surface and evaluation of other concomitant intra-articular pathology and entails only little additional morbidity, especially compared to arthrotomy.

Keywords Intra-articular fracture · Tibial plateau · Arthroscopy-assisted surgery

Introduction

Many different surgical procedures have been developed and used for the management of tibial plateau fractures. There has been controversy regarding indications for closed versus open treatment of tibial plateau fractures. While some authors advocate cast immobilization after either closed reduction or traction, others recommend open reduction and internal fixation. However, these methods usually result in stiffness and decreased range of motion due to lack of early mobilization. Furthermore, associated intra-articular lesions are not recognized and addressed properly. Decreased range of motion soon results in impaired joint cartilage metabolism and increased risk of osteoarthritis [15].

Arthroscopy-assisted surgery was developed for tibial plateau fractures to minimize these disadvantages. It brings the advantage of anatomical reduction in the tibial articular surface through a small incision. Associated intra-articular injuries can also be properly evaluated and treated. Stable fracture fixation can usually be achieved by percutaneous screws. When early postoperative motion can be added to these significant advantages, the risk of stiffness and osteoarthritis is decreased [10]. The purposes of this study were to review the arthroscopy-assisted surgical treatment of tibial plateau fractures and to determine the factors that influence the overall clinical and radiographic results.

Patients and methods

Between January 1994 and January 2000 we treated 49 closed tibial plateau fractures in 48 patients with arthroscopy-assisted surgery. Of these, 45 patients and 46 knees having proper clinical and radiological follow-up were included in this study. There were 11 women and 34 men, and the mean age at the time of injury and treatment was 39 years (range 15–68). The procedure was per-

Table 1 Clinical results according to fracture type, mechanism and other intra-articular pathologies

	n	%	Results			
			Excellent	Good	Fair	Poor
Schatzker fracture type	46	100	16 (35%)	25 (54%)	3 (7%)	2 (4%)
Split condylar	5	11	4	1	–	–
Split and depression	18	39	4	12	1	1
Joint depression	12	26	5	7	–	–
Medial condylar	6	13	3	2	1	–
Bicondylar	3	7	–	2	1	–
Bicondylar with diaphyseal extension	2	4	–	1	–	1
AO/ASIF fracture type	46	100	16 (35%)	25 (54%)	3 (7%)	2 (4%)
A1	0	–	–	–	–	–
A2	0	–	–	–	–	–
A3	0	–	–	–	–	–
B1	9	20	7	1	1	–
B2	12	26	5	7	–	–
B3	20	43	4	14	1	1
C1	3	7	–	2	1	–
C2	1	2	–	1	–	–
C3	1	2	–	–	–	1
Other intra-articular pathologies						
Medial collateral ligament injury	17	39	8	9	–	–
Lateral collateral ligament injury	5	10	2	3	–	–
Anterior cruciate ligament injury	3	6	–	1	1	1
Medial meniscus lesion	8	17	4	3	1	–
Lateral meniscus lesion	15	33	7	7	–	1
Eminentia avulsion fracture	3	7	–	2	1	–
Fracture mechanism						
Traffic accident	26	58	7	16	2	1
Falling down	11	24	3	6	1	1
Sports injury	7	16	4	3	–	–
Other	1	2	1	–	–	–

formed on the right knee in 16 patients, the left knee in 28 and both in one. The cause of injury in all patients is presented in Table 1. Anteroposterior, lateral, and bilateral oblique radiography were obtained in all patients preoperatively. Computed tomography (CT) with three-dimensional reconstruction was performed in 26 patients and magnetic resonance imaging were performed in 8 (Fig. 1). The classification scheme of Schatzker et al. [20] was used for preoperative classification of fracture patterns (Table 1).

Internal fixation was performed using screws only in 31 knees [single screws in 14 (Fig. 2), two or three screws in 17], plate in 8 knees, and plate and screw combination in 7 knees. The fracture involved articular depression 27 patients, in whom lifting and bone grafting with autogenous corticocancellous iliac bone graft was required. Screws only were used for all type 1 and type 3 fractures, plates were used especially in comminuted type 2 fractures and combination of plates and screws was preferred in types 4–6 fractures. Associated injuries are outlined in Table 1. In 23 patients there were also meniscal lesions, which were treated by partial resection in 16 and repaired in 7. We repaired 30% of meniscal lesions. All repaired meniscal lesions were in the peripheral vascular zone. We performed partial resection in 16 patients, 9 of whom had irreparable lesions in the white-white zone and 7 in the red-white zone. We did not perform total meniscectomy in any of the patients.

Mean follow-up was 36 (14–72) months. The postoperative clinical evaluation used the Rasmussen [18] classification, based upon pain, walking capacity, and clinical findings [8] (Table 2). Radiological results were evaluated by the criteria of Resnick and Niwoyama criteria [19], as follows:

- Grade 0: no arthritic changes
- Grade 1: minimal narrowing of joint space, mild sclerosis, no appreciable changes
- Grade 2: moderate narrowing of joint space, osteophyte formation, no bony collapse, moderate subchondral sclerosis, intra-articular osseous bodies, moderate bony aberration
- Grade 3: marked joint space narrowing to obliterated joint space, bony collapse, severe subchondral sclerosis, intra-articular osseous bodies, marked deformity, or angularity severe bony aberration

Operative technique

The patient was positioned supine on the arthroscopy table with the knee flexed to 90°. A knee holder and pneumatic tourniquet were used in all cases. An arthroscope was first inserted into the knee joint through the standard anterolateral parapatellar portal, and irrigation was performed until an adequate vision was obtained. All blood clots, fragments of loose bone, and articular cartilage were removed, and then medial and lateral compartments of the knee were carefully evaluated for any meniscal or ligamentous injury. Injured menisci were trimmed, partially excised, or repaired as indicated following reduction of the fracture. A probe was inserted trough the anteromedial portal to examine the fracture site. Débridement of the fracture site was performed. In cases with de-

Fig. 1 **a** Preoperative anteroposterior radiography of a 38-year-old man with type 2 fracture. **b** The articular surface and the degree of depression and comminution are much better evaluated by computed tomography reconstructions. **c** Postoperative anteroposterior radiography demonstrating restoration of the articular surface

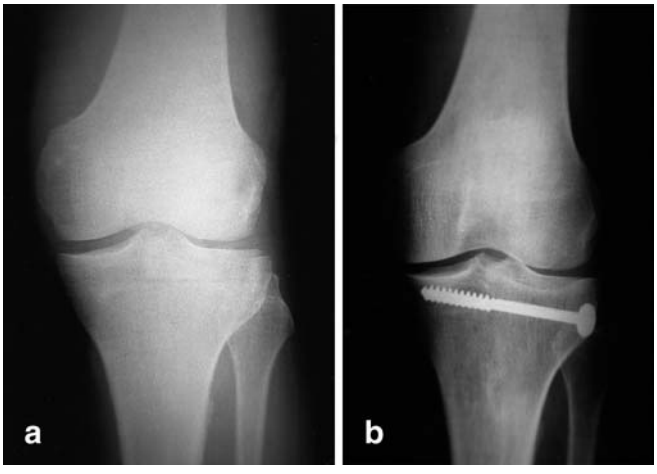

Fig. 2 **a** Preoperative anteroposterior radiography of a 35-year-old man with type 1 fracture. **b** Postoperative radiography at 2 years. Anatomical reduction was obtained and maintained. There is no sign of degeneration and the patient has full range of motion

pressed articular surface fragment a metaphyseal bony window was made, and through this window a Kirchner wire was inserted through the metaphysis and into the center of the displaced fragment. Then a cannulated impactor was used to elevate the subchondral bone and restore the articular surface congruency under the guidance of arthroscopy (Fig. 3). The resultant bone defect was grafted using autogenous iliac crest bone graft. Fracture reduction was once again assessed arthroscopically.

If there was any question on direct visualization, plain intraoperative radiography performed taken. Stable internal fixation was usually achieved by one or two percutaneous cannulated screws. They could be placed percutaneously through separate stab wounds under the control of image intensifier which is necessary for correct and accurate placement. Patients with poor bone quality required buttress plate fixation, which was applied through an extended metaphyseal incision (Fig. 4). In types 5 and 6 fractures reduction was achieved manually under direct vision and image intensifier in the metaphyseal region, and arthroscopy was used for reduction of the intra-articular fragments.

Postoperative cast immobilization was not required, and all patients were mobilized on the second postoperative day with continuous passive motion. Non-weight-bearing walking on crutches continued for approximately 6 weeks, and then partial weight bearing was begun. Full weight bearing was usually begun at 10 weeks, but it took even longer for patients who required lifting and bone graft.

Results

Complete anatomical reduction of fractured fragments was achieved in 35 knees. Up to 2 mm displacement or step-of was accepted for 11 knees. Anatomical reduction was noted to be well maintained in 34 knees, but one developed loss of reduction due to premature weight bearing beyond our control. Results of the postoperative evaluation by the Rasmussen [18] classification are presented in Table 1. Radiological results according to the criteria of Resnick and Niwoyama criteria [19] were: 17 grade 0 (37%), 18 grade 1 (39%), 7 grade 2 (15%), and 4 grade 3 (9%).

As complications one patient developed early deep infection in the first postoperative week; this was successfully healed in 4 weeks after meticulous débridement and intravenous antibiotics. However, infection caused lack of physiotherapy which resulted in moderate stiffness. We had no case of peroneal nerve palsy or nonunion. We performed second-look arthroscopy in three patients. Two were in the second postoperative year at the time of implant removal. Grade 1 chondropathy was noted in all compartments in all three patients, but reduction was maintained in all of them, and they had no complaints.

Discussion

Treatment for fractures of the tibial plateau has involved many different approaches. Closed reduction and cast immobilization was once a rather attractive choice of treatment. Its advantages are avoiding the risk of surgery and short hospital stay. However, a long period of rehabilitation is needed to restore the normal range of motion, and early degenerative changes and findings are not uncommon [1, 11, 12].

Restoration of joint anatomy usually cannot be accomplished by conservative management. Also, diagnosis and treatment of concomitant intra-articular knee pathology cannot be carried out. Long periods of cast immobiliza-

Table 2 Tibial condylar fractures: functional grading, Rasmussen's [18] system

	Points	Outcome evaluation			
		Satisfactory		Unsatisfactory	
		Excellent	Good	Fair	Poor
Subjective complaints					
Pain		5	4	2	1
No pain	6				
Occasional ache, bad weather pain	5				
Stabbing pain in certain positions	4				
Afternoon pain, intense, constant pain around knee after activity	2				
Night pain at rest	0				
Walking capacity		6	4	2	1
Normal walking capacity	6				
Walking outdoors at least 1 h	4				
Short walks outdoors 15 min	2				
Walking indoors only	1				
Wheelchair/bedridden	0				
Clinical signs					
Extension		6	4	2	1
Normal	6				
Lack of extension (0–10°)	4				
Lack of extension (>10°)	2				
Total range of motion		5	4	2	1
At least 140°	6				
At least 120°	5				
At least 90°	4				
At least 60°	2				
At least 30°	1				
0°	0				
Stability		5	4	2	2
Normal stability in extension and 20° of flexion	6				
Abnormal instability 20° of flexion	5				
Instability in extension (<10°)	4				
Instability in extension (>10°)	2				
Sum (minimum)		27	20	10	6

tion or traction and residual stiffness may cause early degeneration of the joint. De Coster et al. [6] followed 30 patients for 10 years after conservative treatment and reported 61% good results. Good short-term results can be obtained with conservative treatment, but long-term results are less encouraging. With regard to walking capacity and pain, good results were reported in two different series consisting of 29 and 46 conservatively treated patients. Their common finding in almost all patients was limited range of flexion and loss of extension. Also, varus or valgus angulation deformity was noted to develop in the long term depending on the fractured tibial plateau [21, 22]. Drennan et al. [7] reported 61 patients who were treated by closed reduction and cast immobilization for tibial plateau fracture. The best results were obtained in patients with split condylar fractures. Closed reduction was not effective for split condylar fractures involving articular depression. Such injuries caused residual deformity and early degeneration. Conservative treatment should be considered only in patients with nondisplaced and stable fractures or when surgical treament is contraindicated. Even then passive knee motion should be started as early as possible with braces permitting motion [22].

A large incision and extensive dissection are usually needed for open surgical repair and manipulation of fractured fragment. However, anatomical reduction still may not be achieved due to inadequate vision. Also, excessive dissection may impair vascularity of the fracture fragments and increase risk of infection [22]. Furthermore, there is usually severe postoperative pain after arthrotomy, and this prevents effective early rehabilitation, leading to some degree of knee joint stiffness.

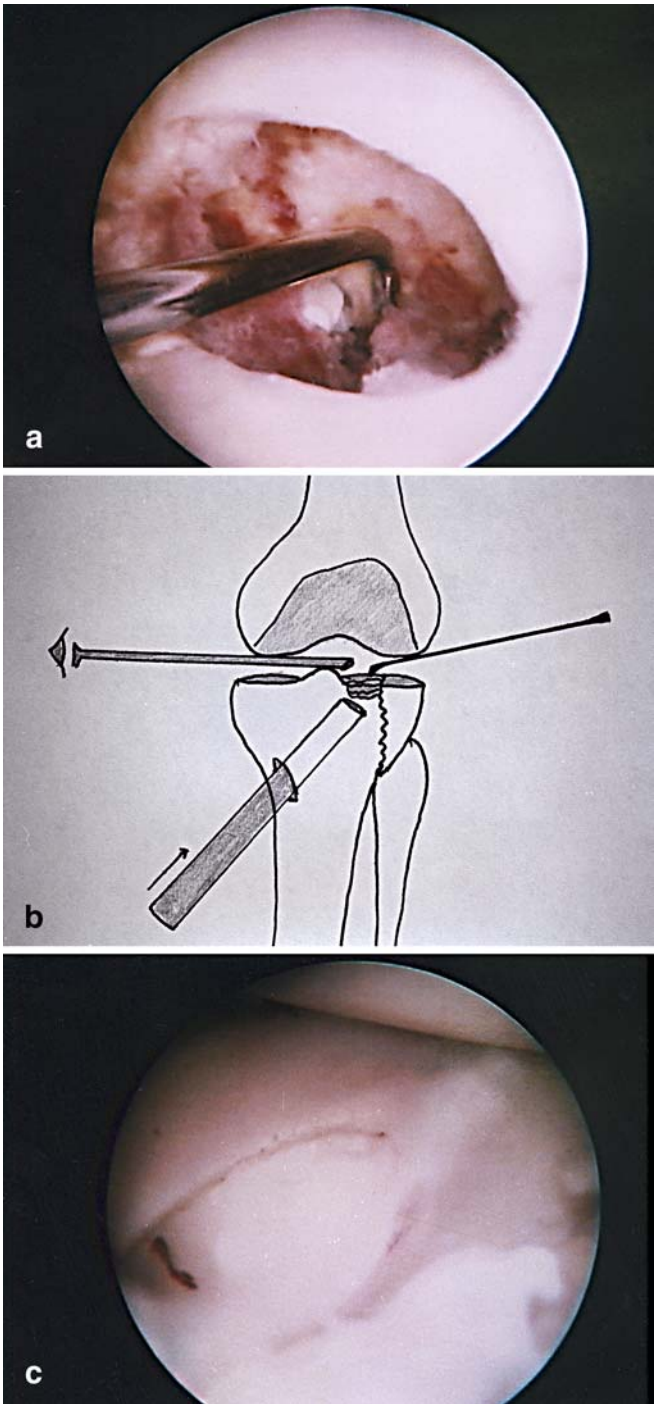

Fig. 3 **a** Arthroscopic appearance of a type 2 fracture. A hook is being used to reduce the depressed articular fragment. **b** A cannulated impactor is used to elevate the subchondral bone and articular surface under the guidance of arthroscopy. **c** Arthroscopic appearance showing restored articular surface right after reduction and screw fixation

Arthroscopy-assisted surgery involves many advantages and is superior to both conservative treatment and open reduction. The use of arthroscopy for treatment of tibial plateau fractures makes it possible to visualize the fracture without arthrotomy or meniscal detachment, achieve anatomical reduction, wash-out all debris, and treat concomitant intra-articular lesions.

The fracture line can sometimes be hidden beneath a meniscus which may prevent proper visualization for anatomical reduction. During the arthroscopic procedure a probe can be used to overcome this problem and confirm reduction. Also, during open reduction the surgeon may need to create meniscal detachment at the meniscocapsular junction for evaluating the reduction. This detachment is repaired at the end of the procedure, but being an additional intra-articular lesion it causes delayed rehabilitation [16]. Arthroscopic surgery involves a very small incision which lessens the postoperative pain. Early rehabilitation can be started, and hospital stay is shortened. It has been demonstrated that early motion postoperatively results in better articular cartilage nutrition and improved healing [4, 10, 11, 14, 15]. It is also more pleasing cosmetically due to less scar formation. Although arthroscopy provided a better cosmetic result in type 1–4 fractures, our purpose and a more important aspect was to ensure anatomical reduction of the intra-articular fragments and treat other intra-articular lesions. We have performed arthroscopy in all types of tibial plateau fractures first for diagnostic and then therapeutic purpose. Although the incision was extended in type 5 or 6 fractures for plate application, we did not open the joint for reduction of fragments which was achieved by arthroscopy.

The degree of articular depression and displacement of fracture fragments is usually considered to be the major factors to determine the need for reduction. Articular depression of 3–8 mm and displacement of 2–10 mm between the fracture fragments have been reported as acceptable limits in the literature, and surgical treatment is indicated in patients with more articular depression and displacement [5, 7, 10, 13, 17]. However, it has been demonstrated in series with long follow-up that residual articular depression or displacement after intra-articular fractures leads to early joint degeneration [5, 12]. These limits are no longer acceptable since the popularization of arthroscopic reduction of intra-articular fractures. Independently of the amount, displacement of fracture fragments and articular surface depression should not be accepted for a load-bearing joint. Anatomical reduction is the major prerequisite which is possible by arthroscopy. Fowble et al. [9] reported the results of treatment in 23 patients with tibial plateau fractures. They performed arthroscopic reduction and percutaneous fixation in 12 and open reduction and internal fixation in 11 patients and compared the final results. They concluded that arthroscopic surgery is more advantageous in terms of anatomical reduction, rate of complication, period of hospitalization, and weight bearing.

Guanche and Markman [11] also used the arthroscopic technique in five patients with tibial plateau fracture and con-

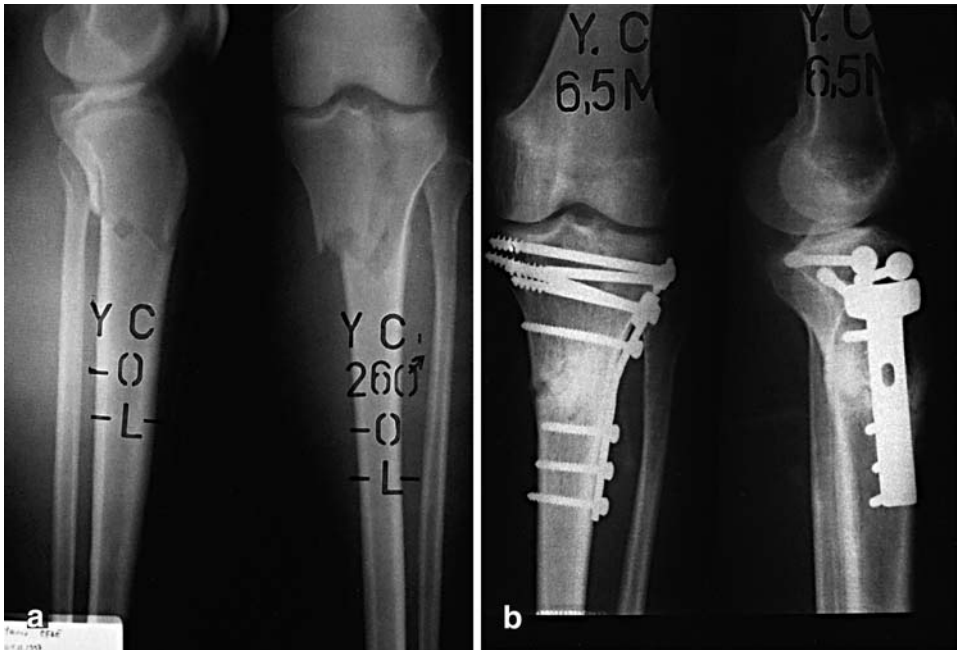

Fig. 4 **a** Preoperative anteroposterior and lateral radiography of a 26-year-old man with type 6 fracture. **b** Postoperative radiography at 6.5 months. Internal fixation was performed using plate and screw combination

cluded that it provides better surgical vision, limited dissection, and decreased rate of infection due to continuous irrigation during surgery. Holzach et al. [12] performed a prospective study in 16 patients with lateral tibial plateau fractures secondary to alpine or cross-country skiing. All but two patients reported resumption of activity to preinjury levels.

The rate of complication related to arthroscopic surgery is reported to be between 1% and 8%. These are either intraoperative complications as vascular or neurological injury, articular cartilage injury, and those due to broken instruments or are early postoperative complications as hemarthrosis, deep vein thrombosis, infection, compartment syndrome, and loss of correction [2, 4, 8]. We had only two major complications in our series, which were loss of correction due to premature weight bearing in one case and one deep infection in the early postoperative period.

There are no clearly established limits for postoperative weight bearing time, but this is usually determined by the pattern of fracture and stability of fixation. Relatively early weight bearing can be allowed in patients having split condylar fractures but no articular depression and loss of bone stock. Full weight bearing should be delayed in those who have fractures involving the condylar contact area or articular depression. It is reasonable for these patients to start weight bearing after 3 months since this is the time required for bone graft consolidation [3, 12]. It is recommended in the literature that partial weight bearing should be started at 4–6 weeks in patients who do not require bone graft and then full weight bearing at 8–10 weeks [3, 10, 15]. This interval for weight bearing is subject to adaptation depending on the fracture pattern, stability of fixation, presence of a concomitant lesion, and age of the patient. Because it avoids arthrotomy and involves continuous irrigation, it is clearly evident that arthroscopic surgery significantly decreases the risk of postoperative infection [3, 12, 15]. We have not confronted any patient with postoperative joint degeneration, but the average follow-up in our series is not long enough to make a definitive comment on this issue.

In conclusion, arthroscopy is an excellent and minimally invasive method for assessment and treatment of tibial plateau fractures. Experience in operative arthroscopy and fracture management is essential to avoid complications and improve long-term results.

References

1. Apley AG (1974) Fractures of the tibial plateau. Orthop Clin North Am 10: 61–74
2. Belanger M, Fedale P (1997) Compartment syndrome of the leg after arthroscopic examination of the tibial plateau fracture. Arthroscopy 13:646–651
3. Berfeld B, Kligman M, Roftman M (1996) Arthroscopic assistance for uncollected tibial plateau fractures. Arthroscopy 12:598–602
4. Buchko MB, Johnson HD (1996) Arthroscopy assisted operative management of tibial plateau fractures. Clin Orthop 332:29–36
5. Carr DE (1991) Arthroscopical assisted stabilization of tibial plateau fractures. Techn Orthop 6:55–57
6. De Coster T, Nepola VJ, El-Khoury GY (1988) Cast brace treatment of proximal tibial fractures. Clin Orthop 231:196–204

7. Drennan DB, et al (1979) Fractures of the tibial plateau treatment by closed reduction and spica cast. J Bone Joint Surg Am 61:989–995
8. Duwelius PJ, Rangitsch RM, Colville RM, Woll ST (1997) Treatment of tibial plateau fractures by limited internal fixation. Clin Orthop 339:47–57
9. Fowble CD, Zimmer JW, Schepsis AA (1993) The role of arthroscopy in the assessment and treatment of tibial plateau fractures. Arthroscopy 9:584–590
10. Gausewitz S, Hohl M (1986) The significance of early motion in the treatment of tibial plateau fractures. Clin Orthop 202:135–138
11. Guanche AC, Marcman AW (1993) Arthroscopic management of tibial plateau fractures. Arthroscopy 9:467–471
12. Holzach P, Matter P, Minter J (1994) Arthroscopically assisted treatment of lateral tibial plateau fractures in skiers. J Orthop Trauma 8:273–281
13. Lansinger O, Bergman B, Körner L, Anderson GBJ (1986) Tibial condylar fracture. J Bone Joint Surg Am 68:13–19
14. Müezzinoğlu SÜ, Güner B, Gürfidan E (1995) Arthroscopically assisted tibial plateau fracture management. Arthroscopy 11:506–509
15. Padanilam GT, Ebraheim NA, Frogameni A (1995) Meniscal detachment to approach lateral tibial plateau fractures. Clin Orthop 314:192–198
16. Perry CR, et al (1984) A new surgical approach to fractures of lateral tibial plateau. J Bone Joint Surg Am 66: 1236–1240
17. Porter BB (1970) Crush fractures of the lateral tibial table. J Bone Joint Surg Br 52:676–687
18. Rasmussen PS (1973) Tibial condylar fractures: impairment of knee joint stability as an indication for surgical treatment. J Bone Joint Surg Am 55:1331–1350
19. Resnick D, Niwoyama G (1981) Diagnosis of bone and joit disorders. Saunders, Philadelphia
20. Schatzker J, McBroom R, Bruce D (1979) The tibial plateau fracture: the Toronto experience (1968–1975). Clin Orthop 138:94–104
21. Scotland T, Wardlaw D (1981) The use of cast bracing as treatment for fractures of the tibial plateau. J Bone Joint Surg Br 63:575–578
22. Tscherne H, Lobenhoffer P (1993) Tibial plateau fractures management and expected results. Clin Orthop 292: 87–100