

High degree of patient satisfaction after percutaneous treatment of lateral tibia plateau fractures

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ABSTRACT

INTRODUCTION: The outcomes and complications following surgical treatment of tibial plateau fractures have been widely reported. The objective of this study was to evaluate the quality of life (QoL), functional and radiological outcomes after lateral tibial plateau fractures, Arbeitsgemeinschaft für Osteosynthesefragen (AO) type 41-B2 and B3, treated with minimally invasive bone tamp reduction, allograft and percutaneous screw fixation.

METHODS: This study was a cross-sectional study and a retrospective review and clinical evaluation of patients treated with minimally invasive bone tamp reduction, allograft and percutaneous screw fixation after lateral tibial plateau fractures between 2005 and 2010. The patients completed a clinical examination, Knee Injury and Osteoarthritis Outcome Score (KOOS) and a questionnaire for evaluation of QoL (Eq5D-5L).

RESULTS: A total of 28 patients agreed to participate (71%). The mean follow-up time was 2.5 years. Maintained anatomical joint reduction and alignment was achieved in 23 cases. The mean Eq5D-5L index was 0.850. The mean KOOS scores were: pain = 79.9, ADL = 80.8, symptoms = 73.0, QoL = 61.3 and sport = 54.4. Compared with Eq5D-5L reference norms, patients did not report significantly lower scores. Compared with a KOOS reference group, patients reported significantly lower KOOS scores in three subscales.

CONCLUSIONS: Tibial plateau fractures AO type 41-B2 and 41-B3 treated with minimally invasive bone tamp reduction, allograft and percutaneous screw fixation showed a high rate of anatomical reduction (82%), a low rate of complications (3.5%) and a high level of satisfactory patient-reported QoL.

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The incidence of tibial plateau fracture in Denmark was recently reported to be 10.3/100,000/year [1]. Conservative management is often not feasible so the majority of fractures are treated operatively [2]. The objective of surgical treatment is anatomical joint reconstruction, rigid fixation and axial alignment [2].

Several studies have evaluated the outcomes of surgical treatment [3-6]. Most studies lack long-term follow-up on both functional and radiological outcomes, as well as on quality of life (QoL). In addition, most studies

do not compare the results to established reference populations.

In general, the complication rate after treatment of tibial plateau fractures is high [7]. Complications such as deep and superficial infection, soft tissue damage, compartment syndrome, deep venous thrombosis (DVT), septic arthritis and additional need for surgery are all observed during the acute phase [2, 7, 8]. Complications following the initial phase include loss of range of motion, ligamentous or meniscal injury, knee instability, pseudoarthrosis and post-traumatic OA, among others [2, 8].

Minimally invasive procedures with bone tamp reduction, allograft and percutaneous screw fixation may be a treatment option with low risk of complications and a high level of satisfactory clinical and patient-reported outcomes for a selected patient group.

The objective of this study was to evaluate the functional and clinical outcomes after lateral tibial plateau fractures (Arbeitsgemeinschaft für Osteosynthesefragen (AO) type 41-B2 and B3) treated with minimally invasive bone tamp reduction, allograft and cannulated percutaneous screw fixation.

METHODS

All patients treated for a tibial plateau fracture between 2005 and 2010 at Aalborg University Hospital, Denmark, were identified from the medical records system. Between 2005 and 2010, 152 patients were treated for a uni-condylar tibial plateau fracture.

Included were all patients with fractures of the lateral tibial plateau, AO type 41-B2 and B3 [9], treated with minimally invasive bone tamp reduction, allograft and percutaneous screw fixation. Excluded were patients with open fractures, fractures treated with open reduction, fixed-angle plates or external fixation. Excluded were also patients with other fractures in the same extremity or patients who had the surgical procedure performed abroad, as well as patients who were unable to fill out the patient-reported questionnaires due to physical or mental disability (**Figure 1**). The Danish Data Protection Agency (R. no. 2010-41-4354) approved this study.

Study design

This study used a cross-sectional design for retrospect-

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ive follow-up. Clinical and radiological outcomes were studied in all patients at follow-up. The baseline characteristics consisted of patient demographics, fracture classification (AO classification [9]) complications and additional damage. Post-surgical follow-up consisted of

radiological outcomes, functional outcome scores, walking ability and QoL. The main outcome measure was the Eq5D-5L.

Operative procedure

During the study period, the departments' standard guideline on treatment of lateral tibial condyle fractures was percutaneous screw fixation with or without grafting. In the treatment period, five experienced trauma surgeons performed all of the procedures. The choice of surgical procedure and the use of grafting materials were at the discretion of the individual surgeons. The operative procedure is described in **Figure 2**.

Outcome measurements

Radiological outcomes: The fracture classification was performed according to the AO classification [9]. The fractures were assessed preoperatively using computer tomography (CT). The presence of osteoarthritis (OA) was evaluated both preoperatively and at follow-up according to Kellgren and Lawrence's [10] recommendations. Articular depression and condylar widening were evaluated using X-rays as described by Rasmussen [11]. For this assessment, one X-ray was taken six weeks post-operatively and another was taken at the time of follow-up. Valgus/varus malalignment was evaluated as described by Browner et al [12]. A valgus/varus malalignment $> 5^\circ$ was considered significant. At follow-up, the X-rays were obtained as bilateral weight-bearing X-rays.

Patient-reported outcome measurements

QoL was assessed using the Eq5D-5L [13], a standardised and validated instrument for assessing health outcomes. Other studies have used the Eq5D-5L for measuring outcomes after tibial plateau fractures [3].

Functional performance was assessed using the KOOS [14]. The KOOS was developed as an instrument for assessing patients' opinions about their knees and associated problems. The instrument was intended for use with knee injuries that could result in post-traumatic AO. A KOOS reference population from southern Sweden was available [15]. Other studies have used the KOOS for measuring outcomes after tibial plateau fractures [2, 3].

Objective outcome measurements

Knee range of motion (ROM) was evaluated using active extension and flexion of the knee with the patients lying supine on the examination table. The patients were asked to do maximal flexion and extension, and the angle was measured with a goniometer.

Procedures

All of the patients were contacted by mail and informed

FIGURE 1

Detailed overview of the recruitment process.

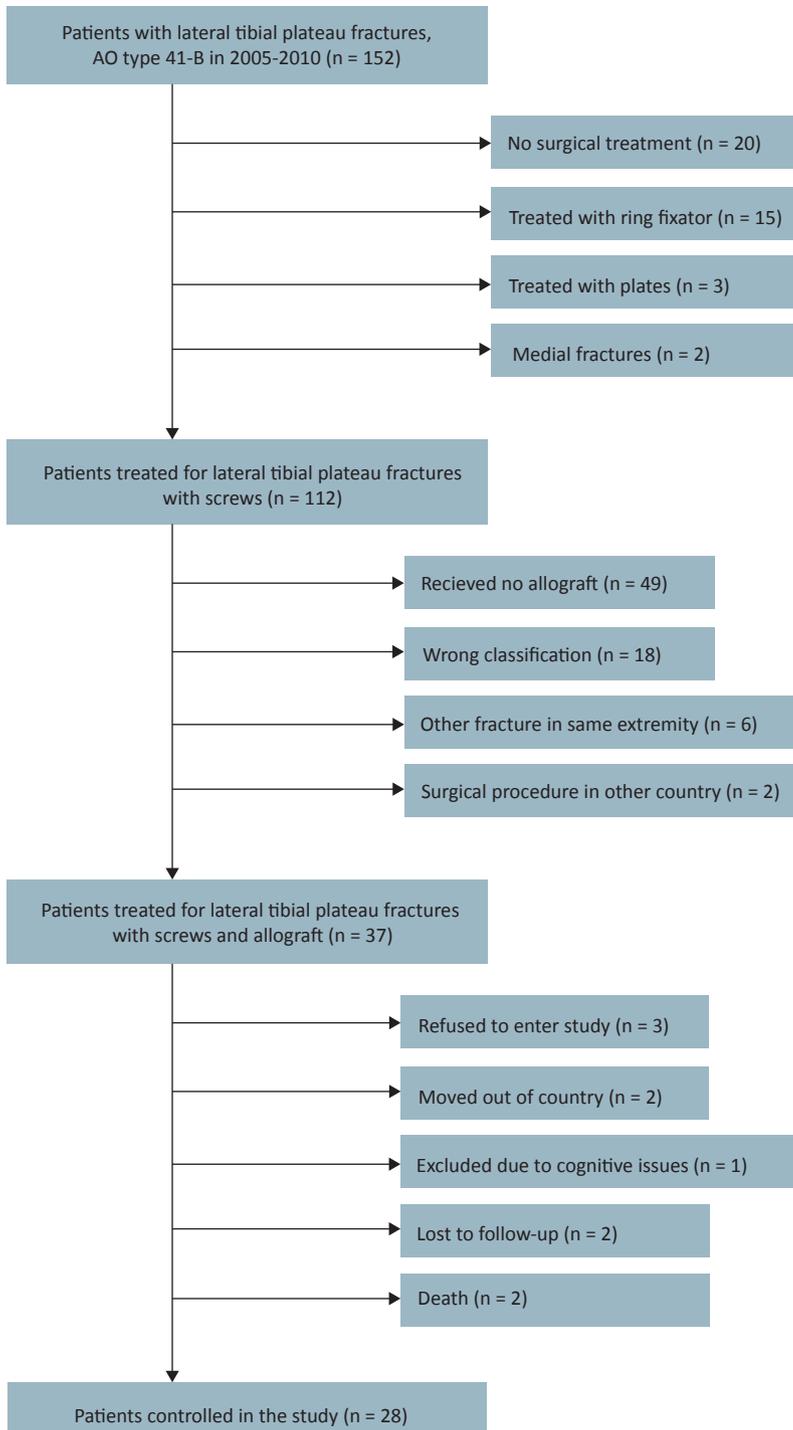


TABLE 1

Demographic patient data.

Patients, total, N	28
Male/female, n	12/16
Age, follow-up, yrs, mean (range)	56.2 (24-79)
Age, surgery, yrs, mean (range)	53.8 (23-77)
AO classification, n	
41-B2	8
41-B3	20
Schatzker classification, n	
Type II	19
Type III	9
Associated injuries ^a , n	2
Follow-up time, yrs, mean (\pm SD)	2.5 (\pm 1.5)

AO = Arbeitsgemeinschaft für Osteosynthesefragen; SD = standard deviation.

a) Multitrauma (n = 1), lesion of the peroneal nerve (n = 1).

about the study. They were then invited to attend a clinical evaluation in August 2011. Mean values, standard deviations (SD) and 95% confidence intervals (CI) are given. Due to the small number of patients (n = 28), statistical analyses were not performed.

Trial registration: not relevant.

RESULTS

A total of 28 patients were enrolled in this study (71%). The mean age at the time of surgery was 53.8 years with a range of 23-77 years. The mean follow-up time was 2.5 (SD = 1.5) years. In this study, 57% of the patients were women. Baseline characteristics are presented in **Table 1**.

A total of 19 fractures were classified as AO type 41-B3 and nine as 41-B2 fractures. Associated injuries were found in two patients: one with multitrauma and one with a preoperative lesion of the peroneal nerve. Complications were present in one patient who developed complex regional pain syndrome (CRPS). Additional surgical procedures were performed in eight cases. Additional surgery included the removal of screws after union (n = 7) and a total knee alloplastic (TKA) procedure (n = 1).

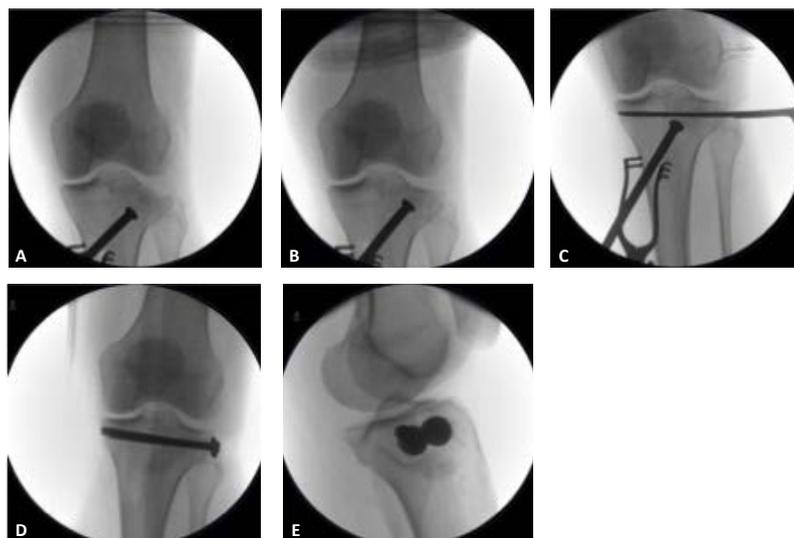
Radiological outcomes

Post-operatively, 24 patients achieved anatomical joint reduction and alignment. At the time of follow-up, anatomical joint reduction and alignment were achieved in 23 cases.

The patient who developed subsidence between six weeks post-operatively and the time of follow-up had a further depression of 10 mm evaluated on anteroposterior and side X-rays. At follow-up, inadequate reduction

FIGURE 2

Surgical procedure. After drawing fracture lines and landmarks on the patients, a 3-cm incision was made facing the anterior of the tibia. The periosteum was held aside and a canal was drilled with an 11-mm cannulated coring reamer with collar pin, guided by fluoroscopy. Through the intramedullary canal, the goal was to reduce the joint anatomically, visualised by intraoperative fluoroscopy in multiple planes (**A** and **B**). Bone allograft chips were prepared from a caput femoris allograft from the local bone bank. The caput femoris was cleaned from soft tissue and cartilage and appropriately sized bone allograft chips were prepared using a bone mill. The allograft chips were introduced and stamped into place below the fracture guided by fluoroscopy (**C**). Finally, the fracture was fixed with a minimum of two percutaneous 7.3-mm screws introduced from the lateral side (**C**, **D** and **E**). Additional screws were placed as needed. All patients were immobilised in an angle-stable brace with the ability to control range of motion. They started physiotherapy the first day after surgery by attending a post-operative rehabilitation protocol. Patients were kept non-weight-bearing for six weeks post-operatively, and radiology was obtained preoperatively and at six weeks post-operatively.



was present in five cases with > 5 mm depression of the joint surface and three cases presented with valgus/varus deformity > 5°.

At follow-up, four cases presented with Kellgren-Lawrence Type 1, five cases with Type 2, eight cases with Type 3 and one with Type 4. Before surgery, signs of radiological OA were present in eight cases: three cases with Type 1, four cases with Type 2 and one case with Type 3.

Patient-reported outcomes

The mean Eq5D-5L index was 0.850 (CI: 0.799-0.900) and the mean Eq5D-5L VAS was 82.9 (CI: 77.5-88.3). Compared with the established Danish reference population [16], no significant difference was observed (**Table 2**). The mean KOOS subscale scores were as follows: pain = 79.9 (CI: 71.2-88.5), ADL = 80.8 (CI: 72.6-88.7), symptoms = 73.0 (CI: 63.8-82.2), QoL = 61.3 (CI: 49.8-72.8) and sport = 54.4 (CI: 41.2-67.7). Compared with the established KOOS reference population [15], the patients in this study reported significantly lower KOOS scores for the subscales symptoms, QoL and sport (**Table 2**).

TABLE 2

Patient-reported outcome measurements. The values are mean (95% CI).

	Index	VAS	Pain	ADL	Symptoms	QoL	Sport
<i>Eq5D-5L</i>							
Study population	0.85 (0.799-0.900)	82.9 (79.5-88.3)	–	–	–	–	–
Reference population, male/female, 50-59 yrs ^a	0.888/0.858 (0.880-0.896/0.850-0.866)	–	–	–	–	–	–
<i>KOOS</i>							
Study population	–	–	79.9 (71.2-88.5)	80.8 (72.6-88.7)	73 (63.8-2.2)*	61.3(49.8-72.8)*	54.4(41.2-67.7)*
Reference population ^b	–	–	– (86.7-88.2)	– (86.5-88.1)	– (85.4-86.9)	– (77.4-79.6)	– (72.5-75.1)

ADL = activities of daily living; CI = confidence interval; Eq5D-5L = questionnaire which evaluates QoL; KOOS = Knee Injury and Osteoarthritis Outcome Score; QoL = quality of life; VAS = visual analogue scale.

*) Significantly different compared with reference population.

a) [16].

b) [6].

TABLE 3

Outcome according to anatomical reduction at follow-up.

	Anatomical reduction	Inadequate reduction
Patients, total, N	23	5
Male/female, n	10/13	2/3
Age, follow-up, yrs, mean (range)	54.4 (24-77)	64.6 (59-79)
Follow-up time, yrs, median (range)	2.0 (1-5)	4.0 (1-5)
<i>Kellgren-Lawrence, n</i>		
Type 0-1	14	0
Type 2-3	9	4
Type 4	0	1
<i>KOOS, median (range)</i>		
Pain	93.0 (36-100)	58.0 (33-100)
Symptoms	79.0 (25-100)	71.0 (36-100)
ADL	88.0 (43-100)	66.0 (40-100)
Sport	67.5 (0-100)	40.0 (5-100)
QoL	50.0 (25-100)	38.0 (33-100)
<i>Eq5D-5L, median (range)</i>		
Index	0.856 (0.611-1.0)	0.797 (0.7-1.0)
VAS	82.5 (50-100)	83.0 (64-100)
<i>Pain, n</i>		
Rest (yes/no)	4/19	3/2
Activity (yes/no)	7/16	3/2
<i>ROM, °, median (range)</i>		
Flexion	131.9 (115-145)	125.0 (115-135)
Defect compared with other side	7.3 (0-15)	12.0 (5-20)
Unable to walk > 1 km, n	3	3

ADL = activities of daily living; Eq5D-5L = questionnaire which evaluates QoL; KOOS = Knee Injury and Osteoarthritis Outcome Score; QoL = quality of life; OM = knee range of motion; VAS = visual analogue scale.

Objective outcomes

The mean knee flexion was 130.0° with a range of 115-145°.

Compared with the opposite knee, the mean movement deficit was 10.0° with a range from 0-20°. Two patients had extension deficits of > 5°. Six patients reported that they were unable to walk more than 1 km.

Outcomes according to maintained anatomical reduction

A comparison of the group that maintained anatomical reduction with the group that had inadequate reduction is presented in **Table 3**. The group with inadequate reduction presented an inferior outcome in their post-operative OA score, KOOS scores, ROM, Eq5D-5L and the ability to walk more than 1 km. The group with inadequately maintained reduction of the fractures tended to be older and the follow-up times were longer than in the group with anatomically reduced fractures.

DISCUSSION

This study shows that treatment of a selected patient-group with lateral tibial plateau fracture using minimally invasive bone tamp reduction, allograft and percutaneous screw fixation is a safe and reliable method that has a high rate of union, a low rate of complications and satisfactory patient-reported outcomes.

At a mean 2.5 years after surgery, the Eq5D-5L values were not significantly worse compared with the established Danish reference norms. To the best of the authors' knowledge, this is the first study to use reference norms from an established reference population to evaluate the long-term patient-reported QoL after tibial plateau fractures treated with minimally invasive bone tamp reduction, allografts and percutaneous screw fixation.

A small number of studies have used patient-reported outcome measures, but only a single study used a disease-specific, patient-reported questionnaire [2]. However, that study did not compare the findings to those of a reference population. Compared with the established KOOS reference population [15], the patients in the present study reported significantly lower KOOS scores on three subscales, which is a novel finding. The KOOS subgroup sport was the most limited, which is in

line with findings from other studies [3]. The limitations in the KOOS subscale sport may be due to the fact that even small functional deficits of the knee joint reduce the patient's ability to participate in sports.

The patients in the present study were treated with minimally invasive bone tamp reduction, allograft and percutaneous screw fixation. Subsequently, 82% achieved anatomical reduction, which is in line with, or better than, other studies reporting this surgical method [4, 5]. These results are comparable to those reported for other surgical methods [4, 8, 9].

In this study, the patients who had inadequately reduced fractures also had poor functional outcomes and restrictions in QOL compared with the other patients. These findings were in line with those reported in previous research [8]. However, Koval et al [4] did not find this association. The findings in the present study support the notion that proper anatomical reduction of the articular surface is essential for functional outcomes, QOL and the development of post-traumatic OA after treatment for tibial plateau fractures.

All of the patients in this study who had an inadequate anatomical reduction of the fracture at the time of the follow-up had an AO type 41-B3 fracture. Those with AO type 41-B2 fractures all achieved anatomical reduction. In addition, 47% of the AO type 41-B3 fractures had anatomical reduction at the time of the follow-up. Other studies using closed reduction and percutaneous screw fixations for tibial plateau fractures reported the same trend. The reasons for these findings are not clear. This may be due to the lowered ability to adequately reduce the fracture components in AO type 41-B3 fractures during the temporary widening of the lateral condyle plateau.

Operative treatment of tibial plateau fractures is associated with a number of complications, including deep and superficial infections, compartment syndrome, pseudoarthrosis, pain, ROM restrictions and post-traumatic OA. All of these complications may lead to restrictions in activity and QOL. The incidence of complications following operative treatment for tibial plateau fractures is reported to be between 3% and 56% [2, 17]. High-energy trauma patients with soft-tissue injuries are reported to have the highest incidence of complications [2, 17]. The patients included in the present study had a low complication rate of 3.5%.

The authors have previously reported on lateral tibial condyle fractures treated with percutaneous screw fixation without the use of grafting [6], also in the period from 2005-2010, and shown results that are comparable to those of the present study group. However, the results are both retrospective and no conclusions regarding the effect of grafting can be drawn from these studies.

This study has a number of limitations. First, it is a retrospective study with a small, select group of patients. Because of the cross-sectional design, the time to follow-up was variable. Second, the mean follow-up period was 2.0 years. Studies of lower-extremity trauma have demonstrated changes in outcomes with the length of follow-up [18]. Volpin et al [19] reported that the incidence of post-traumatic OA following intra-articular fractures of the knee tended to develop from six to eight years after injury. These findings are in line with the findings in the present study which show worse outcomes for patients with a longer follow-up period.

Moreover, the decision concerning operative procedure and the use of allografting was made by the individual surgeon at the time of treatment and this may potentially cause bias.

CONCLUSIONS

This study shows a high rate of anatomical reduction (82%), a low rate of complications (3.5%) and a high level of satisfactory patient-reported QOL in a selected patient group treated with minimally invasive bone tamp reduction, allograft and percutaneous screw fixation following a lateral tibial plateau fracture.

Nevertheless, the patient-reported KOOS scores were significantly below the established reference population in three of five subscales.

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