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Original article

# Unicondylar fractures of the distal femur

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A B S T R A C T

*Background:* Unicondylar fractures of the distal femur are rare, complex, intra-articular fractures. The objective of this multicentre study was to assess the reduction and fixation of unicondylar fractures.
*Hypothesis:* Anatomic reduction followed by strong fixation allows early rehabilitation therapy and provides good long-term outcomes.
*Material and methods:* We studied 163 fractures included in two multicentre studies, of which one was retrospective ($n = 134$) and the other prospective ($n = 29$). Follow-up of at least 1 year was required for inclusion. The treatment was at the discretion of the surgeon. Outcome measures were the clinical results assessed using the International Knee Society (IKS) scores and presence after fracture healing of malunion with angulation, an articular surface step-off, and/or tibio-femoral malalignment.
*Results:* Mean age of the study patients was $50.9 \pm 24$ years, and most patients were males with no previous history of knee disorders. The fracture was due to a high-energy trauma in 51% of cases; 17% of patients had compound fractures and 44% multiple fractures or injuries. The lateral and medial condyles were equally affected. The fracture line was sagittal in 82% of cases and coronal (Hoffa fracture) in 18% of cases. Non-operative treatment was used in 5% of cases and internal fixation in 95% of cases, with either direct screw or buttress-plate fixation for the sagittal fractures and either direct or indirect screw fixation for the coronal fractures. After treatment of the fracture, 15% of patients had articular malunion due to insufficient reduction, with either valgus-varus (10%) or flexion-recurvatum (5%) deformity; and 12% of patients had an articular step-off visible on the antero-posterior or lateral radiograph. Rehabilitation therapy was started immediately in 65% of patients. Time to full weight bearing was 90 days and time to fracture healing 120 days. Complications consisted of disassembly of the construct (2%), avascular necrosis of the condyle (2%), and arthrolysis (5%). The material was removed in 11% of patients. At last follow-up, the IKS knee score was $71 \pm 20$ and the IKS function score $64 \pm 7$; flexion range was $106 \pm 28°$ ($< 90°$ in 27% of patients); and 12% of patients had knee osteoarthritis.
*Conclusion:* Anatomic reduction of unicondylar distal femoral fractures via an appropriate surgical approach, followed by stable internal fixation using either multiple large-diameter screws or a buttress-plate, allows immediate mobilisation, which in turn ensures good long-term outcomes.
*Level of evidence:* IV, cohort study.

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## 1. Introduction

Unicondylar fractures of the distal femur are rare lesions [1–3] that often occur in combination with other post-traumatic injuries and may therefore fail to be recognised initially. They are caused by

a direct impact on the flexed knee during weight bearing [4]. The fracture line starts in the lateral or medial intercondylar-trochlear groove. At the lateral condyle, the fracture line radiates either in the coronal plane, detaching the most posterior part of the condyle (Hoffa fracture or AO-33 B3 [B3] type fracture); or in the sagittal plane, in an oblique upwards and lateral direction (Trélat fracture or AO-33 B1 [B1] type fracture) [5]. At the medial condyle, the fracture line is rarely in the coronal plane (Hoffa fracture or AO-33 B3 [B3] type fracture) and more often in the sagittal plane (Trélat fracture

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or AO-33 B2 [B2] type fracture) [4–6]. Fracture lines located more posteriorly tend to be located in a more coronal plane [7].

Post-traumatic osteoarthritis is among the complications of intra-articular unicondylar distal femoral fractures [4,8]. Fractures of the lateral condyle carry a risk of malalignment and of degenerative disease of the patello-femoral compartment due to comminution of the cartilage at the anterior part of the fracture line [7]. Avascular necrosis is a potential complication of posterior unicondylar fractures with marked displacement.

To date, no consensus exists regarding the treatment type, surgical approach, or optimal internal fixation technique for unicondylar distal femoral fractures [6,7,9,10].

Our objective was to evaluate correlations linking early and late functional and anatomic outcomes to the treatment used in a multicentre cohort of patients with unicondylar distal femoral fractures. We hypothesised that anatomic reduction and strong fixation would lead to good long-term outcomes by allowing early rehabilitation therapy.

## 2. Patients and methods

Two multicentre studies, one retrospective and the other prospective, were conducted in 12 surgical centres.[1]

Patients with unicondylar fractures of the distal femur were included. Exclusion criteria were pathological fracture, periprosthetic fracture of the knee, child younger than 15 years and 3 months, and epiphyseal separation. In all, 163 patients were included. The retrospective cohort consisted of 134 assessable cases managed over a 10-year period (1 January 2001–31 December 2010) and the prospective cohort of 29 patients managed over a 1-year period (1 June 2011–31 May 2012). Follow-up was at least 1 year in all patients. The medical record data and the pre-operative and post-operative radiographs were entered into an online database, as well as the computed tomography (CT) scans obtained in 39% of patients. The data were used initially to validate the classification of the fracture in the AO system [5].

The treatment type and modalities were at the discretion of the surgeon, who could choose between non-operative treatment and operative treatment via an anterior or posterior approach with internal screw or plate fixation. Immediate mobilisation was an option, with no more than 60° of flexion for the first 45 days. Resumption of weight bearing was allowed of the radiographs taken after 2 months showed that the fracture was healed.

Fracture site deformities after treatment were assessed on antero-posterior and lateral radiographs and classified as malunion with more than 2° of angulation, a greater than 2 mm articular surface step-off, or tibio-femoral malalignment exceeding 5°. Congruity of the lateral or medial tibio-femoral compartment and patello-femoral compartment was assessed. The International Knee Society (IKS) knee and function scores were determined at last follow-up [11]. Clinical and radiographic follow-up was provided for at least 1 year, and the data at last follow-up were recorded.

Statistical comparisons relied on the $Chi^2$ test, non-parametric Fisher test, and non-parametric Mann-Whitney test. Values of $P \leq 0.05$ were considered significant.

## 3. Results

### 3.1. Epidemiology

The study population was composed predominantly of males, with an active lifestyle and no history of knee abnormalities (95%)

**Table 1**
Epidemiological data.

| $n = 163$ | |
| --- | --- |
| Age (years), mean ± SD | 50,9 ± 24 [17–93] |
| Male/Female ratio | 1,6 |
| Side: Right/Left (%) | 51/49 |
| Compound fracture (%) | 17 |
| Multiple fractures (%) | 44 |
| Knee osteoarthritis (%) | 5 |
| *Type of trauma (%)* | |
| Fall from standing height | 42 |
| Fall from high place | 8 |
| 2-wheel motor vehicle accident | 23 |
| Car accident | 11 |
| Pedestrian-motor vehicle accident | 5 |
| Sports accident | 4 |
| Other | 7 |
| *AO-33 B Fracture type (%)* | |
| 66 B1 | 40 |
| 68 B2 | 42 |
| 29 B3 | 18 |
| *Treatment (%)* | |
| Surgical/non-surgical | 95/5 |

(Table 1). Mean age was 50.9 ± 24 years (range, 17–93 years). The fracture was due to a high-energy trauma in 51% of cases. In addition, 17% of patients had compound fractures and 44% had multiple fractures or injuries.

Of the 163 fractures, 134 (82%) were sagittal, including 66 lateral B1 fractures and 68 medial B2 fractures. The remaining 29 (18%) lesions were coronal B3 fractures.

### 3.2. Treatments

Non-surgical treatment was chosen in 9 (5%) patients. These patients were young individuals with non-displaced fractures, or patients with very limited functional demands, elderly patients with osteoporosis, or patients with B3 posterior unicondylar fractures. The treatment consisted only in a very short period of immobilisation, followed promptly by mobilisation of the knee.

Surgical treatment was performed in 154 (95%) patients. Table 2 lists the intra-articular lesions documented during surgery. Of the patients with B1 fractures, 5% had damage to the lateral meniscus and 8% to the cruciate ligaments. Of patients with B2 fractures, 2% had lesions of the medial meniscus and 9% of the cruciate ligaments. Finally, among patients with B3 fractures, 12% had meniscal lesions and 23% lesions of the cruciate ligaments.

Table 3 shows the approaches and internal fixation methods used in the 154 surgically treated patients. The approach was antero-lateral for B1 fractures and antero-medial for B2 fractures. Among B3 fractures, 78% were managed via an antero-lateral or antero-medial approach and 22% via a postero-lateral or postero-medial approach. Fixation of B1 and B2 fractures was usually achieved using screws or buttress-plates (Fig. 1a and b) (95%); in a few cases (5%), staples or pins were used. Fixation of B3 fractures relied on screws in 93% of cases; in 78% of cases, lag screws were inserted anteriorly (Fig. 2a) and in 15% screws were inserted directly via a posterior approach (Fig. 2b). In the remaining 7% of B3 fractures, fixation was with staples or pins.

**Table 2**
Intra-articular lesions documented during surgery.

| AO-33 B type $n = 154$ (%) | Lateral meniscus (%) | ACL (%) | Medial meniscus (%) | PCL (%) |
| --- | --- | --- | --- | --- |
| B1 (40) | 5 | 3 | | 5 |
| B2 (42) | | 6 | 2 | 3 |
| B3 (18) | 8 | 15 | 4 | 8 |

ACL: anterior cruciate ligament; PCL: posterior cruciate ligament.

**Table 3**
Approaches and internal fixation techniques.

| Type AO-33 B n = 154 (%) | Lateral plate (%) | Medial plate (%) | Transverse screws (%) | Antero-posterior screws (%) | Postero-anterior screws (%) | Other (%) |
|---|---|---|---|---|---|---|
| B1 (40) | 23 | | 72 | | | 5 |
| B2 (42) | 13 | 4 | 78 | | | 5 |
| B3 (18) | | | | 78 | 15 | 7 |
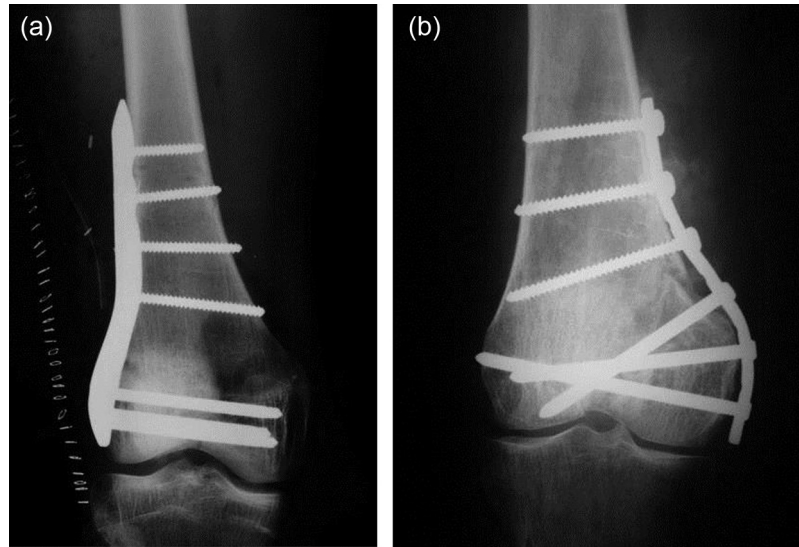


**Fig. 1.** a: AO-33 B1 type unicondylar fracture: internal fixation using a lateral buttress-plate; b: AO-33 B2 type unicondylar fracture: internal fixation using a medial buttress-plate.

### 3.3. Short-term outcomes

Rehabilitation therapy was started immediately in 65% of cases, with full weight bearing after 90 days. None of the patients required joint manipulation under anaesthesia for stiffness. No difficulties with skin management occurred in the patients with compound fractures. There were no cases of infection. Fracture healing was achieved within 120 days. Disassembly of the construct occurred in 2% of cases, after simple screw fixation with small-diameter screws ($P = 0.05$). Avascular necrosis of the posterior condyles was noted in 2% of cases, in patients managed via a posterior approach ($P = 0.04$). Secondary arthrolysis was required in 5% of patients and removal of the fixation material after fracture healing in 11% of patients. After 1 year, 50% of patients had returned to their previous job, the mean IKS knee score was $71 \pm 20$, and the mean IKS function score was $64 \pm 7$.
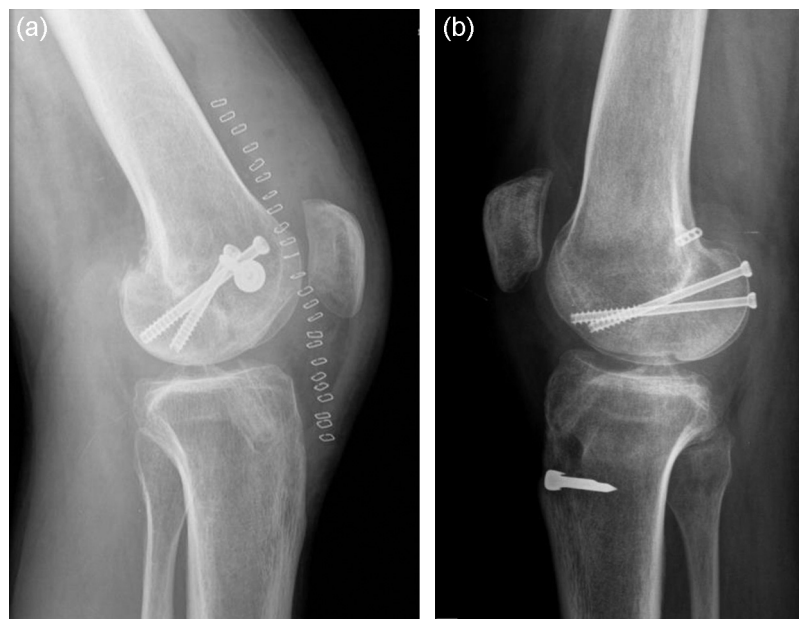


**Fig. 2.** a: AO-33 B3 type unicondylar fracture: internal fixation using multiple antero-posterior lag screws; b: same type of fracture: direct internal fixation via a postero-anterior approach.

**Table 4**
Radiological intra-articular malunion after fracture healing.

| Type AO 33 B n = 163 (%) | Valgus (%) | Varus (%) | Flessum (%) | Recurvatum (%) | Step-off on AP view (%) | Step-off on lateral view (%) |
|---|---|---|---|---|---|---|
| B1 (40) | 2 | 2 | 4 | | 8 | |
| B2 (42) | 2 | 9 | 2 | 4 | 14 | |
| B3 (18) | | | | | | 12 |

AP: antero-posterior.

Table 4 reports the data on the intra-articular malunions, which were consistently due to insufficient reduction. Valgus-varus deformity was present in 10% of cases, flexion-recurvatum deformity in 5%, and an articular surface step-off visible on the antero-posterior (Fig. 3a) or lateral view in 12%. Tibio-femoral alignment was similar to that of the contralateral lower limb (difference, 2.8°±2.4°). Joint congruity at the lateral or medial tibio-femoral compartment and patello-femoral compartment was normal in 90% of patients.

### 3.4. Outcomes at last follow-up

Mean follow-up was 7 years. At last follow-up, the clinical evaluation showed moderate pain in 50% of patients and complete absence of pain in 46%, with a mean flexion range of 106°±28°. Among patients with malunion, 27% had less than 90° of knee flexion ($P = 0.02$) and the radiographs showed no worsening of the deformity (Fig. 3a). Evidence of osteoarthritis was found in 12% of patients and was associated with malunion ($P = 0.03$). The presence of osteoarthritis led, in some cases, to treatment with osteotomy (3%) or total knee arthroplasty (2%).

### 4. Discussion

The main limitations of this study are the multicentre patient recruitment, retrospective data collection for most of the patients, and variability in practice patterns across surgical teams. A major strength of our study is the large sample size of 163 fractures. Previously published data are difficult to interpret, as they come from small non-randomised studies that did not involve statistical analyses [1,3,8,12–15].

The 82%/18% distribution of sagittal and coronal fractures in our study is consistent with earlier reports. In contrast, the similar number of lateral and medial condylar fractures is at variance with a report by Trillat et al. that the lateral condyle was affected more often than the medial condyle [4].

CT was performed pre-operatively in 39% of our patients. CT provides an evaluation of the displacement, detects comminution of the fracture site, and helps to choose the best approach and fixation method [10]. Our study does not provide information on whether CT provided useful therapeutic guidance.

High-grade skin lesions with damage to the extensor mechanism [16] or injuries to vessels and nerves [1,9] are extremely rare in patients with unicondylar fractures. Such lesions were not present in any of our patients. However, some patients had intra-articular ligament or meniscus lesions (Table 2), which are not usually reported in studies of unicondylar fractures.

Non-operative treatment without fracture reduction was chosen in 9 (5%) of our patients, in conformity with standard indications [2,7]. Surgery was performed in 154 (95%) patients, also according to standard indications. In patients with non-displaced fractures, surgery may be required because of a risk of displacement during cast immobilisation or of joint stiffness due to the immobilisation [4,12]. The need for surgery is even more obvious in patients with displaced fractures, to reduce the displacement, ensure fixation of the articular fracture site, and allow early mobilisation. The two major difficulties that limit the indications of surgical treatment are the location of the fracture line [17] and the limited holding power of the fixation material for posterior B3 fractures [2,7,18].

Our hypothesis regarding the anatomic reduction of unicondylar fractures is not borne out by our findings, since 27% of patients had radiographic intra-articular malunion, which was consistently due to insufficient reduction. The resulting abnormalities were valgus-varus deformity in 10% of cases, flexion-recurvatum deformity in 5%, and an antero-posterior or lateral articular surface step-off in 12%. Only very few cases of malunion have been reported in earlier studies of small numbers of patients. Selection of the approach has a major influence on the ability to achieve stable anatomic reduction [17,19]. The approach must allow not only reduction of the displacement, but also adequate positioning of the fixation material. The conventional anterior approaches are often too limited to
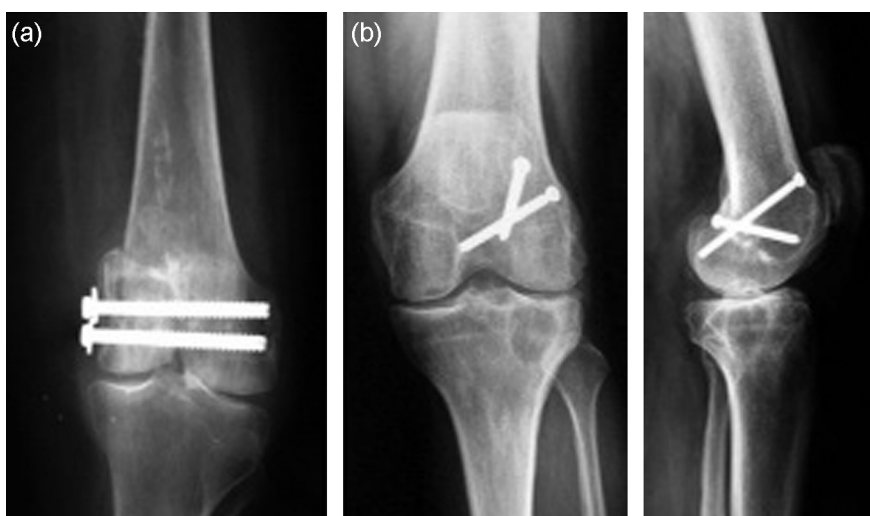


**Fig. 3.** a: radiographs showing insufficient reduction on the post-operative antero-posterior view; b: after 10 years, the antero-posterior and lateral views show anatomic reduction.

ensure adequate fracture site exposure, anatomic reduction, and strong fixation. As a result, extended anterior approaches are used [17,19], in particular for posterior unicondylar fractures [20,21]. Our study did not provide data on potential variations in reduction according to the approach used. In contrast, posterior approaches were chosen for posterior B3 fractures [9] and were associated with secondary avascular necrosis due to disruption of the blood supply, in keeping with earlier data [4,14].

Regarding our hypothesis that strong internal fixation allows early rehabilitation therapy, 65% of our patients started rehabilitation therapy immediately. Buttress-plates provide stronger fixation than do screws. A lateral buttress-plate was used in 23% of B1 fractures and a medial buttress-plate in 4% of B2 fractures. Screw fixation was used alone for all B3 fractures. For anatomic reasons, only anterior lag screws are perpendicular to the fracture line. These screws were used in 78% of patients. However, regardless of the anatomic features, direct posterior-to-anterior screw fixation via a posterior approach is stronger than lag screw fixation [22]. This method was used in 15% of patients. In clinical practice, posterior direct screw implantation starts at a postero-medial or postero-lateral point of the posterior condyle, and the screws are oriented in a more or less transverse direction relative to the fracture line, which results in less mechanical strength and tilts the fragment to some extent [4]. The insult to the cartilage can be limited by using headless screws [23]. Furthermore, disassembly of the construct was associated with the use of small-diameter screws in our study. In keeping with this finding, biomechanical studies of multiple-screw fixation have established that 6.5 mm screws provide greater strength than do 3.5 mm screws [24].

The functional outcomes at last follow-up in our study (IKS knee score, $71 \pm 20$; IKS function score, $64 \pm 7$; and flexion range, $106° \pm 28°$ with less than $90°$ of flexion in 27% of cases) were associated with the presence of malunion [2,8,9,15]. Many factors can contribute to knee stiffness. Among them, some are unrelated to the fracture, such as concomitant damage to the menisci and ligaments or the presence of multiple injuries or fractures [1]. Motion range limitation has been reported in other studies [4,7,9].

The mean follow-up of 7 years in our study is too short to allow definite conclusions about the risk of osteoarthritis. The development of osteoarthritis was associated with post-operative malunion.

## 5. Conclusion

Non-operative treatment of unicondylar distal femoral fractures is indicated in patients with limited functional needs or severe osteoporosis. Surgical treatment via an appropriate anterior approach allows anatomic reconstruction and strong internal fixation, using screws or a buttress-plate for sagittal fractures and lag screws for coronal fractures. Anatomic reduction followed by immediate mobilisation ensures good functional outcomes with no progression to osteoarthritis.

## Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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