Coronal Fractures of the Femoral Condyle
A Brief Report of Five Cases
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Summary: Coronal fractures of the femoral condyle (Hoffa fractures) are uncommon injuries that have a better outcome when treated surgically. We report a series of five Hoffa fractures (including one nonunion) treated at a Level I trauma center by one surgeon employing a protocol of open reduction and internal fixation with lag screws through a formal parapatellar approach. Postoperatively, all patients began immediate unrestricted range of motion. Initial weight bearing was limited, but all patients were permitted full weight bearing by 10 weeks. All fractures healed within 12 weeks without complications. The final range of motion for the patients with acute fractures was at least 0° to 115°. The patient with a nonunion had a preoperative flexion contracture of 20° and a final range of motion of 20° to 125°. Long-term follow-up (average 37 months, range 18-57 months) was available for 3 of the 5 patients, and Knee Society scores were calculated for these patients (average 173 of 200 points, range 160-180 points). The literature regarding the management of Hoffa fractures is reviewed.

Key Words: Hoffa, femoral condyle, articular fracture

MATERIALS AND METHODS
Five patients with isolated Hoffa fractures (AO/OTA 33.b3.2) presented to the senior author (M.R.B.) and were treated using a standardized protocol. The average age of the patients was 51 years (range 37–70 years). Three fractures were medial, and two were lateral. The mechanism of injury was a motor vehicle accident in four patients and a fall in one patient. Four patients were treated acutely; one was treated following a referral for a symptomatic nonunion after nonoperative treatment. Three of the four acutely treated patients had concomitant skeletal injuries requiring concurrent intervention, but none of these compromised immediate functional treatment of the knee joint. The preoperative radiographs, computed tomography (CT) scan, intraoperative images, and postoperative radiographs from one of the patients with an acute fracture are shown in Figures 1 to 4.

Surgical Technique
A midline incision is made, and a medial or lateral parapatellar arthrotomy is performed over the involved condyle, preserving the fat pad. After routine joint inspection, the fracture is displaced with a bone spreader and debrided. The fracture is anatomically reduced and held compressed with pointed Weber bone clamps. Drilling for screw placement is initiated just proximal to the patellofemoral joint, is directed perpendicular to the fracture line, and continues deliberately through the articular surface of the posterior condyle. This allows for exact length measurement and assists in maintaining the spread and parallelism of the remaining screws (Fig. 3). Following overdwelling, multiple parallel 3.5-mm screws are placed across the fracture site from anterior to posterior. Depending on the quality of the anterior cortex, screws can be countersunk, or a small plate functioning as a washer can be used (Fig. 4).

The tourniquet times ranged from 45 to 74 minutes. Blood loss was less than 150 mL in all patients except the patient with the nonunion, who required iliac crest bone grafting. Postoperatively, all patients began unrestricted immediate...
FIGURE 1. Anteroposterior and lateral radiographs of coronal plane fracture of the distal femur. The step-off on the lateral condyle is clearly visible on both views.

FIGURE 2. Sagittal plane computed tomographic reconstruction of distal femoral Hoffa fracture. Note the separation of the tibiofemoral joint from the patellofemoral joint and shaft by the fracture. Shearing forces along the fracture plane increase with knee extension.

FIGURE 3. Temporary coronal and epicondylar fracture stability is achieved with Weber pointed forceps and pelvic reduction clamps to allow for lag screw fixation. The posterior condylar articular surface is breached to facilitate exact measurement for implant length and to maximize lag screw purchase.

range of motion. Initial weight-bearing status was limited, but all patients were allowed full weight bearing within 10 weeks.

RESULTS
At 12 weeks, all fractures were healed clinically and radiographically. There were no superficial or deep infections or hardware removals. All patients had a documented range of motion of 0° to at least 115° except the patient with the non-union, who had a severe preoperative flexion contracture of 20° and whose range of motion when lost to follow-up after 5 months was 20° to 125°. Long-term follow-up (average 37 months, range 18–57 months) was available for 3 of the 5 patients. Their average Knee Society score was 173 (average 160–180).
Hoffa fractures are rare injuries, and lateral fractures are more common than medial fractures. They usually occur as an isolated injury to the involved femur, but bilateral Hoffa fractures and unilateral bicondylar Hoffa fractures have been reported. In addition, Hoffa fractures associated with supracondylar intercondylar (AO/OTA 33C) femur fractures have been observed, and the reporting authors highlight the need for preoperative detection of the Hoffa fracture to select the appropriate fixation method for the supracondylar fracture.

The specific mechanism of injury that produces the Hoffa fracture is unknown, but a shearing force on the posterior femoral condyle is postulated. Lewis et al argued that axial load to the lateral femoral condyle with the knee in 90° or more of flexion produces posterior tangential fracture patterns. Four of seven patients in their series were riding motorcycles at the time of injury, placing the knee in 90° of flexion and positioning the lateral femoral condyle to receive an impact. The Hoffa fracture effectively separates the patellofemoral joint from the tibiofemoral joint; knee movement and particularly weight bearing cause high shear forces along the fracture line, making nonoperative management unpredictable and adequate stabilization challenging.

Examination invariably identifies effusion, but varus and valgus instability may be subtle. The neurovascular status should be assessed as in all high-energy knee injuries. Initial anteroposterior and lateral radiographs may be unimpressive because Hoffa fractures, especially when nondisplaced, are sometimes difficult to detect. On the anteroposterior view, the foreshortened fractured condyle may lead to the appearance of varus or valgus malalignment. On a true lateral view, the femoral condyles are not superimposed, and this may be misinterpreted as a poor radiographic view of a normal knee (Fig. 1). Oblique radiographs may be helpful, but if the standard radiographic views do not confirm and define the fracture, a CT scan is necessary (Fig. 2).

In an attempt to predict which coronal plane fractures of the femoral condyle would progress to avascular necrosis, Letenneur et al proposed dividing Hoffa fractures into three types, based on the distance of the fracture line from the posterior cortex of the femoral shaft. A subsequent report from Lewis et al failed to validate this classification. The AO Comprehensive Classification of long bone fractures and the OTA Fracture Compendium identify the unicondylar coronal fracture as 33.b3.2 but provide little information about prognosis or treatment.

Although it is generally accepted that surgical stabilization is necessary to achieve satisfactory function following a Hoffa fracture, the few reports in the literature that describe operative treatment do not outline clearly a straightforward, dependable treatment approach with its underlying rationale, and they vary considerably with respect to the surgical approach, postoperative protocol, and outcome measures. There is a dearth of specific information on the preferred management of this fracture in several popular orthopaedic fracture management texts. We found 18 articles concerning the management of Hoffa fractures; 5 of these reports simply included Hoffa fractures as a part of a series of unicortical distal femur fractures. The report of Lewis et al on seven coronal fractures of the lateral femoral condyle represents the largest single group of patients studied, but only five fractures were treated operatively. They used either a medial parapatellar arthrotomy or a direct lateral approach between the iliotibial band and the biceps tendon to expose the fracture and two nonparallel screws to fix it. Postoperatively, patients were placed in cylinder casts for 2 to 6 weeks depending on the stability achieved intraoperatively. All five fractures treated surgically healed, and at final follow-up (average 13 months), knee range of motion averaged 110° (range 95° to 130°).

Two reports of arthroscopically assisted reduction and internal fixation of femoral condyle fractures have appeared. Wallenbock and Ledinski reported a series of 24 intraarticular knee fractures that they treated with arthroscopically assisted reduction and internal fixation, which included two Hoffa fractures. Although noting that the technique of arthroscopically assisted reduction is demanding, they reported good early results. They did not describe specifically the technique or outcome of the patients with coronal fractures. McCarthy and Parker described a patient with a sagittal plane lateral femoral condyle fracture. Although their fixation did not appear to achieve rigid compression, they cited reduced soft tissue dissection, blood loss, and operative time and a faster recovery time after arthroscopic management as advantages over formal open reduction. It is difficult to conclude from these two reports that arthroscopically assisted reduction and internal fixation has any clear advantage over the open technique.
Ostermann et al\textsuperscript{19} emphasized fracture compression and rigid internal fixation to allow immediate postoperative knee motion in their report on the long-term (average 68 months) results of 29 unicortylar femur fractures, of which there were six Hoffa fractures. They did not describe their surgical approach or the outcomes of the patients with Hoffa fractures, but they noted that 23 of 27 patients available for follow-up had an excellent result.

Manfredini et al\textsuperscript{5} surgically treated 19 patients with unicortylar femur fractures, six of which were Hoffa fractures, using a variety of open reduction and internal fixation techniques. Four patients with unicortylar femur fractures were treated nonoperatively in casts. Of the patients treated surgically, 16 were available for follow-up at a mean of 60 months; 11 had good or excellent results, and 5 had fair or poor results. The four patients treated nonoperatively had an unfavorable outcome, with three fair and one poor result.

Liebergall et al\textsuperscript{20} described a lateral approach to the knee, using an ostectomy of Gerdy's tubercle, in the treatment of a lateral coronal condylar fracture, but did not offer any outcome data on this single case. The authors argued that the ostectomy permits improved visualization for open reduction and internal fixation.

A cadaveric study compared the stiffness and load to failure of 3.5-mm cortical lag screws, 4.5-mm cortical lag screws, and 6.5-mm cancellous screws used to fix experimentally created Hoffa fractures.\textsuperscript{21} There was no difference in stiffness between any of the groups, but the load to failure was significantly higher for 6.5-mm screws compared with 3.5-mm screws. The investigators questioned whether that result was clinically significant and noted that smaller screws, such as 3.5-mm cortical screws, may be much easier to fit around a rigid implant if such fixation is necessary, as in the case of a supracortylar femur fracture with an associated Hoffa fracture.

Commonly referenced orthopaedic fracture management textbooks offer a paucity of information regarding the preferred surgical management of Hoffa fractures. One major text\textsuperscript{14} does not even mention this fracture pattern. Muller and Allgower's Manual of Internal Fixation\textsuperscript{15} includes a diagram of a Hoffa fracture fixed with two anteroposterior screws but does not offer a text description. Schatzker and Tile\textsuperscript{16} described the Hoffa fracture pattern and noted that nonoperative treatment of Hoffa fractures leads to poor function but otherwise did not offer a management approach.

Our series of five operatively treated isolated Hoffa fractures is unique in that, in contrast to the reports of Lewis et al\textsuperscript{4} and Manfredini et al,\textsuperscript{5} we employed a standardized surgical approach to the fracture and achieved rigid fixation with optimally positioned lag screws placed perpendicularly to the fracture plane. We believe that an ipsilateral parapatellar approach provides the visualization of the fracture and articular surface necessary for achieving a perfect anatomic reduction and the exposure to compress and rigidly fix the fracture with multiple lag screws. The excellent fracture stability that is achieved allows for unrestricted immediate range of motion of the joint, minimizing the risk of postoperative joint ankylosis. As more fractures are managed with limited open and percutaneous techniques, the Hoffa fracture pattern stands out as one that still is managed best by a “low-tech” formal open reduction and classic lag screw fixation. In our hands, this method has led to uniformly good results without complications.

REFERENCES


