The Association Between Supracondylar-Intercondylar Distal Femoral Fractures and Coronal Plane Fractures

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Background: Isolated coronal plane fractures of the distal femoral condyles (Hoffa fractures) occur uncommonly, are difficult to diagnose, and may be challenging to treat. The combination of supracondylar distal femoral fractures and these coronal plane fractures is thought to occur rarely. The purposes of the present study were to identify the frequency of the association between supracondylar-intercondylar distal femoral fractures and coronal fractures of the femoral condyle and to describe the radiographic evaluation of these injuries.

Methods: One hundred and eighty-nine patients with 202 supracondylar-intercondylar distal femoral fractures were retrospectively evaluated clinically and radiographically.

Results: Coronal plane fractures were diagnosed in association with seventy-seven (38.1%) of the 202 supracondylar-intercondylar distal femoral fractures. Fifty-nine (76.6%) of these coronal fractures involved a single condyle, and eighteen involved both the medial and lateral femoral condyles. Eighty-five percent of the coronal fractures involving a single condyle were located laterally. Patients with an open distal femoral fracture were 2.8 times more likely to have a coronal plane fracture than patients with a closed fracture were (95% confidence interval, 1.54 to 5.25). Coronal plane fractures were diagnosed in 47% of the 102 knees that were evaluated with computerized tomography, compared with 29% of the 100 knees that were not ($p = 0.008$). Ten coronal plane fractures that had been unrecognized preoperatively were identified only at the time of operative fixation of the distal femoral fracture; none of these fractures occurred in patients who had been evaluated with computerized tomographic scanning preoperatively.

Conclusions: Coronal plane fractures frequently occurred in association with high-energy supracondylar-intercondylar distal femoral fractures; in the present study, the prevalence of associated coronal plane fractures was 38%. The lateral condyle was involved more frequently than the medial condyle was. Coronal plane fractures of both condyles were observed commonly, and the majority of coronal plane fractures were associated with open wounds. Since the surgical tactic for the treatment of a supracondylar-intercondylar distal femoral fracture may be altered by the additional diagnosis of a coronal plane fracture component, preoperative computerized tomographic scanning of the injured distal part of the femur, particularly when there is an associated open wound, is strongly recommended.

Level of Evidence: Prognostic Level II. See Instructions to Authors for a complete description of levels of evidence.

In 1904, Hoffa described an isolated coronal plane fracture of the posterior aspect of the femoral condyle[1]. This type of fracture has been reported to involve the lateral condyle more commonly[2], but fractures of the medial condyle have been described as well[2,3]. Nonoperative treatment has been associated with displacement and poor functional results[2-4]. Operative treatment has therefore been recommended[2-9]. These fractures represent a diagnostic dilemma, are frequently missed, and are associated with further displacement if unrecognized[2,4,8,9]. Computerized tomographic scanning has been recommended as an adjunct in the diagnosis of condylar involvement in patients with intra-articular distal femoral fractures[2,5].

Operative treatment also has been recommended for patients with combined supracondylar and intercondylar femoral fractures because it has been found to provide stable restoration of the articular surface and to facilitate early range of motion[10-18]. The association between intercondylar distal fem-

oral fractures and coronal plane fractures of the distal femoral articular surface has received little attention[7,17] despite numerous reports on distal femoral fractures[4,10-21]. Preoperative recognition of these injuries may assist with the planning of surgical approaches and the selection of implants for fixation. The purposes of the present study were to identify the association between supracondylar-intercondylar distal femoral fractures and coronal plane fractures of the distal femoral articular surface and to describe the radiographic evaluation and diagnosis of these injuries.

Materials and Methods

All patients who had sustained an intra-articular fracture of the distal part of the femur between May 1994 and April 2003 were identified through a search of a prospective orthopaedic database, and their records and radiographs were reviewed retrospectively. These fractures were classified according to AO and Orthopaedic Trauma Association (OTA) criteria[22]. Two hundred and ninety-four patients with 310 intra-articular distal femoral fractures were identified and were included in the initial review. One hundred and five patients with 108 unicondylar (OTA type-33-B) injuries were excluded. The remaining 189 patients with 202 supracondylar-intercondylar distal femoral fractures survived the initial resuscitation and were managed operatively at Harborview Medical Center, a level-1 trauma center in Seattle, Washington.

Two fellowship-trained orthopaedic traumatologists (S.E.N. and D.N.S.) reviewed all preoperative and postoperative radiographs, computerized tomographic scans, and operative notes to identify these associated coronal plane fractures. To determine the ability to identify the coronal fracture fragment or fragments on plain radiographs, the anteroposterior and lateral radiographs that had been made at the time of the injury were critically assessed prior to review of the computerized tomographic scans (if available). The postoperative radiographs and the operative notes detailing the surgical findings were assessed after the initial review of the radiographs that had been made at the time of the injury.

Statistical comparisons were carried out with use of chi-square analysis performed with Stata 7.0 software (Stata, College Station, Texas).

Results

All Supracondylar-Intercondylar Fractures (Type 33-C)

The study group included 120 male and sixty-nine female patients with an average age of 46.1 years (range, fourteen to ninety-six years). The mechanism of injury was a motor-vehicle accident for 101 patients, a fall from a height for thirty-seven, a motorcycle accident for twenty-four, a pedestrian-motor-vehicle accident for nine, a remote ballistic injury for six, a crush injury for three, and miscellaneous injuries for nine. The 202 fractures were classified according to AO/OTA guidelines as type 33-C1 (seventeen), type 33-C2 (eighty-nine), or type 33-C3 (ninety-six)[22]. Thirteen patients had a bilateral fracture. All injuries in which a sagittal intercondylar fracture was associated with a coronal plane fracture of either condyle were classified as type 33-C3. One hundred and two fractures (50%) were open and were classified according to the system of Gustilo and Anderson[23] as type I (three), type II (fourteen), type IIIA (seventy-eight), type IIIB (three), or type IIIC (four).

Subset of Fractures with Associated Coronal Plane Fractures

Coronal plane fractures of the femoral condyles ultimately were diagnosed in association with seventy-seven (38.1%) of the 202 supracondylar-intercondylar distal femoral fractures (Figs. 1-A through 1-D). This subgroup included forty-seven male and twenty-nine female patients with a mean age of 42.8 years (range, fifteen to ninety-six years). (One patient had a bilateral fracture.) The mechanisms of injury were similar to those for the entire group and included a motor-vehicle accident for forty-six patients, a fall from a height for seven, a motorcycle accident for eleven, a pedestrian-motor-vehicle accident for five, a remote ballistic injury for two, and miscellaneous injuries for five. (One patient had a bilateral fracture.) In eighteen extremities, coronal plane fractures involving both the medial and lateral femoral condyles were identified. In fifty-nine extremities, a single coronal plane fracture was identified laterally (fifty extremities; 85%) or medially (nine extremities; 15%). Of the ninety-five coronal plane fragments, sixty-eight were displaced and twenty-seven were nondisplaced. Eight of these coronal plane fractures were further categorized as segmental injuries with multiple condylar fragments.

Diagnosis, Associated Open Wounds, and Injury Severity

Sixty-six percent (fifty-one) of the seventy-seven distal femoral fractures with an associated coronal plane fracture were open (with nine injuries classified as Type II, thirty-eight classified as Type IIIA, two classified as Type IIIB, and two classified as Type IIIC), compared with 41% (fifty-one) of the 125 distal femoral fractures without an associated coronal plane fracture ($p < 0.001$). Open fractures occurred in 89% (sixteen) of the eighteen extremities with both medial and lateral coronal plane fractures. Patients with an open supracondylar-intercondylar distal femoral fracture were 2.8 times more likely to have at least one associated coronal plane fracture than those who had a closed distal femoral fracture were (95% confidence interval, 1.54 to 5.25).

The average Injury Severity Score[24] for the entire group of 189 patients was 17.5 (range, 9 to 59). The average Injury Severity Score was 19.1 (range, 9 to 59) for patients with an associated coronal plane fracture, compared with 16.5 (range, 9 to 59) for patients without a coronal plane fracture ($p = 0.08$). The average Injury Severity Score for patients with a coronal plane fracture of both condyles (19.1) was the same as the score for the patients with a coronal plane fracture of only one condyle.

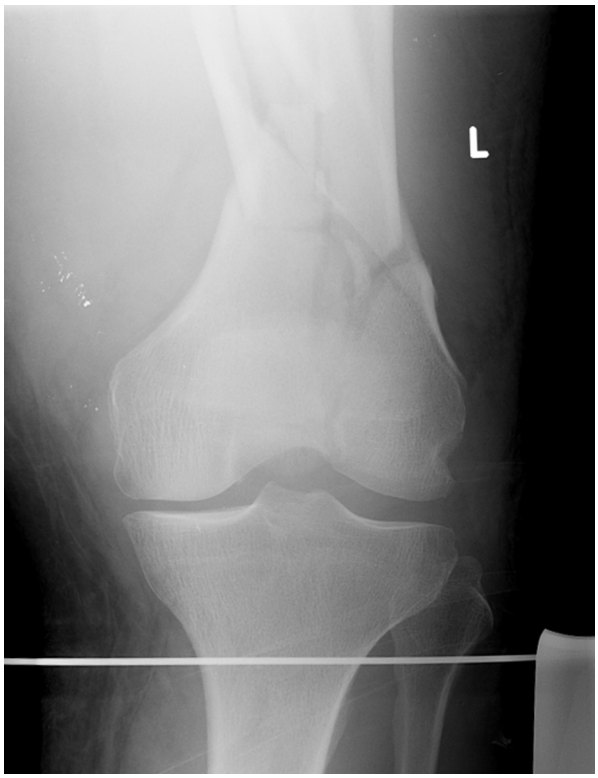

Fig. 1-A

Fig. 1-B

Figs. 1-A through 1-D A sixty-four-year-old man sustained a supracondylar-intercondylar distal femoral fracture in a motor-vehicle accident. **Fig. 1-A** Anteroposterior radiograph demonstrating the intercondylar extension and a slight double overlap of the lateral condyle. **Fig. 1-B** Lateral radiograph clearly demonstrating the displaced coronal plane condylar fracture.

These injuries were diagnosed on the basis of plain radiographs, computerized tomographic scans, or intraoperative direct visual inspection. Biplanar distal femoral plain radiographs were diagnostic of only sixty-six (69%) of the ninety-five coronal plane fragments in the fifty-nine knees with a fracture involving a single condyle and the eighteen knees with a fracture involving both the medial and lateral condyles. A computerized tomographic scan of the distal part of the femur was performed for only 102 of the 202 knees in the present study. The identification of a coronal plane fracture was dependent on the method of diagnosis. Coronal plane fractures were diagnosed in 47% of the 102 knees that were evaluated with computerized tomographic scanning, compared with only 29% of the 100 knees that were not ($p = 0.008$). Computerized tomographic scans were more likely to be made as part of the preoperative evaluation as time progressed over the nine years of this study; specifically, computerized tomographic scanning was performed for only two (4.2%) of forty-eight patients during the first three years of the study, compared with sixty-five (76.5%) of eighty-five patients during the final three years. This difference in the frequency of computerized tomographic scanning during the final three years was related to the evolving philosophy regarding the treatment of these injuries. In ten patients, none of whom had had computerized tomographic scanning, the diagnosis of a coronal plane fracture was discovered only during intraoperative inspection. In two of these patients, the coronal plane fracture was only appreciated during insertion of the angled blade-plate seating chisel as the posterior condylar fragment displaced during attempted fixation of a presumed type-33-C2 fracture. In both patients, this fracture was subsequently reduced and stabilized while the surgical implant was changed from an angled blade-plate to a lateral condylar buttress plate.

Discussion

The presence of a coronal plane fracture in association with an intra-articular distal femoral fracture has received little attention, despite numerous publications on distal femoral fractures[4,10-21]. The complexity of the fractures in our series reflects the patient population at a primary and tertiary referral level-1 trauma center. Of the 202 supracondylar-intercondylar distal femoral fractures in the present study, only seventeen were true "T" intercondylar fractures without articular or metaphyseal-diaphyseal comminution (type-33-C1 fractures). The presence of a coronal plane fracture in association with an intercondylar fracture necessitates classification as a type-33-C3 fracture because the articular surface is multifragmentary. Overall, only nineteen (20%) of ninety-six type-33-C3 distal femoral fractures did

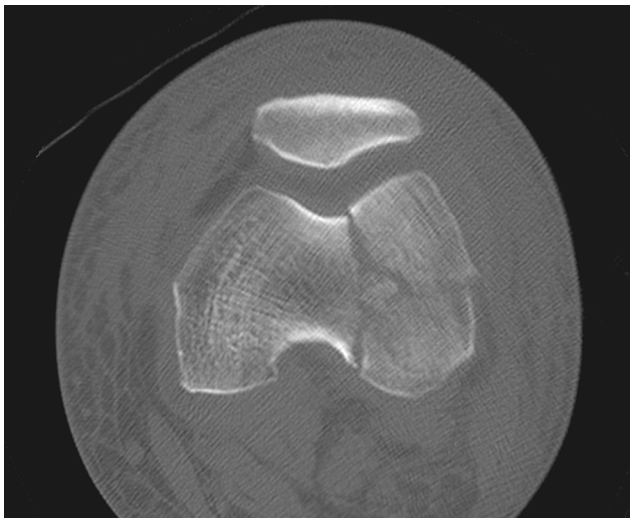

Fig. 1-C

Axial (Fig. 1-C) and sagittal reformatted (Fig. 1-D) computerized tomographic scans confirming and further delineating the injury pattern.

Fig. 1-D

not have an associated coronal plane fracture. The presence of a coronal fracture in association with 38% of all supracondylar-intercondylar distal femoral fractures is important because the surgical approach and implant choice may be altered on the basis of this finding.

In both unicondylar fractures[8,9] and isolated Hoffa fractures[2,3,5,8,9], the lateral condyle is involved more frequently than the medial condyle is. In two previous series, all thirteen isolated Hoffa fractures involved the lateral condyle[3,9]. In the present series, fifty (85%) of the fifty-nine coronal fractures involving a single condyle were located laterally. However, medial condylar coronal plane fractures were not as uncommon as expected. While the occurrence of a bicondylar (medial and lateral) coronal plane fracture without an intercondylar or supracondylar fracture has been reported previously[6], the occurrence of a bicondylar coronal plane fracture in association with a supracondylar-intercondylar distal femoral fracture has not been reported previously, to our knowledge. This combination occurred in eighteen (9%) of the 202 extremities in the present series and in 24% of the patients with at least one coronal plane fracture. Since the surgical approach for fixation of distal femoral fractures usually is from the lateral side, preoperative identification of a medial coronal plane fracture can be critical to surgical decision-making.

Identification of these injury patterns can be difficult, and no single method can be universally recommended. Plain radiographs, computerized tomography, and visual inspection all may be useful for diagnosis and surgical planning. Recognition of these injuries (especially nondisplaced fractures) on the basis of just anteroposterior and lateral plain radiographs is often difficult. Oblique radiographs[4] and computerized tomographic scans[2,5] have been recommended to facilitate the diagnosis of these injuries. In the present series, computerized tomographic scans were made inconsistently. This inconsistency was partly due to the need for emergent treatment of patients who had open fractures and associated vascular injuries. However, the heightened awareness and recognition of the frequency of these associated injury patterns and the greater ease of obtaining imaging studies in the emergency room led to the more frequent use of computerized tomographic scanning over the nine years of this study. While visual inspection may be considered one of the best diagnostic tools, direct visualization of the medial femoral condyle is not routine during most surgical exposures of the distal part of the femur. As medial condylar involvement was found in 13% (twenty-seven) of the 202 distal femoral fractures in this series, anticipation of these fractures while planning the surgical approach may assist with their treatment. Furthermore, computerized tomographic scans with sagittal reformatting often demonstrate nondisplaced fractures, including those without complete disruption through the articular surface, better than direct visual inspection does, and thus computerized tomography may be the most helpful diagnostic tool with which to identify these injuries preoperatively. This is especially true in cases in which the planned approach does not include direct visualization of the articular surface.

In the present series, in which most (96.5%) of the patients had sustained blunt trauma, open fractures constituted 50% of the injuries. The prevalence of associated open traumatic wounds in patients with distal femoral fractures has been reported to range from 17% to 31%[16,19]. However, the prevalence of open wounds among patients with comminuted distal femoral fractures has been reported to be higher (40% to

56%)[7,17], which is consistent with the findings in our series. The prevalence of open fractures in the present study (50% of all AO type-33-C fractures) is reflective of a high-energy mechanism of injury. Consistent with the high prevalence of comminution in patients with combined distal femoral and coronal plane fractures, the prevalence of associated open wounds increased to 59% (thirty-five of fifty-nine) in association with fractures involving a single condyle and to 89% (sixteen of eighteen) in association with combined medial and lateral coronal plane fractures. An associated coronal plane fracture was almost three times more likely to occur in a patient with an open supracondylar-intercondylar distal femoral fracture than in a patient with a closed fracture. A heightened awareness of this injury pattern should alert the clinician to fully evaluate all open distal femoral fractures for the presence of associated condylar comminution.

The present study had several limitations. Specifically, the present study was a retrospective review of a nonhomogeneous group of patients with differing radiographic evaluations and surgical approaches. The high-energy nature of the injuries observed in the present series may not reflect the prevalence of associated coronal plane fractures seen in patients with lower-energy supracondylar-intercondylar distal femoral fractures. However, the actual prevalence of coronal plane fractures in this series of high-energy injuries may actually be underestimated as computerized tomographic scans were not made for almost half of the patients, especially early in the study period. Potentially, a number of patients could have had nondisplaced coronal plane fractures that did not displace and remained unrecognized at the time of surgical stabilization. The natural history of untreated or unrecognized, nondisplaced coronal plane fractures in association with supracondylar-intercondylar distal femoral fractures remains unknown.

In conclusion, coronal plane fractures were identified in association with 38.1% of the 202 supracondylar-intercondylar distal femoral fractures, a prevalence that was higher than expected. In addition, coronal plane fractures of both the medial and lateral femoral condyles were identified in association with 8.9% of all distal femoral fractures and 23.4% of injuries with at least one associated coronal plane fracture. Coronal plane fractures involving only one condyle affected the lateral condyle much more frequently than the medial condyle (85% compared with 15%). An open injury was associated with a nearly threefold increased risk of an associated coronal plane fracture. The diagnosis often was missed on plain radiographs, with only 69% of coronal plane fractures being identified with this method of imaging. Computerized tomographic scanning improves the diagnostic yield and can help substantially in preoperative planning. ■

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