A Proposed Classification of Supracondylar Femur Fractures Above Total Knee Arthroplasties

Edward T. Su, MD, Erik N. Kubiak, MD, Hargovind DeWal, MD,
Rudi Hiebert, BS, and Paul E. Di Cesare, MD

Abstract: A new classification system is proposed for supracondylar femur fractures above total knee arthroplasties based on fracture location relative to the femoral component. Radiographs of 28 cases were evaluated and classified according to the proposed system by 12 physicians: 3 trauma specialists, 3 adult reconstruction specialists, 3 musculoskeletal radiologists, and 3 orthopaedic residents. The same 12 physicians reevaluated the same 28 cases 3 months later. The mean reliability coefficient for all observers was 0.74 (substantial agreement). The coefficient for reproducibility after 3 months was 0.85 (almost perfect). The power of the study was 80%. The proposed classification system is easy to use and has good interobserver reliability among orthopaedic residents, orthopaedic attendings—trauma and reconstruction—and radiologists. Intraobserver reliability was also excellent at 3 months. **Key words:** periprosthetic, femur, fracture, total knee arthroplasty, radiographs, classification.

Supracondylar periprosthetic femur fractures above total knee arthroplasties are an uncommon complication after total knee arthroplasty, with a reported incidence of 0.3% to 2.5% [1-3]. These fractures are most common in elderly patients with osteoporosis and such other risk factors as rheumatoid arthritis, neurological disorders, chronic steroid therapy, femoral anterior cortical notching, and revision knee arthroplasty [1,4,5]. The usual mechanism of injury is a fall directly onto the flexed knee.

From the Department of Orthopaedic Surgery, Musculoskeletal Research Center, NYU-Hospital for Joint Diseases Orthopaedic Institute, New York, New York.
Submitted June 30, 2003; accepted May 15, 2005.
No benefits or funds were received in support of the study.
Reprint requests: Paul E. Di Cesare, MD, Department of Orthopaedic Surgery, Musculoskeletal Research Center, NYU-Hospital for Joint Diseases Orthopaedic Institute, 301 East 17th Street, Room 1501, New York, NY 10003.

0883-5403/06/1906-0004$32.00/0
doi:10.1016/j.arth.2005.05.022

There are several interpretations of what constitutes "the supracondylar region of the distal femur." Neer et al [6] in 1967 defined it as the lower 3 in (7.62 cm) of the femur (see Table 1). Culp et al [4] specified 9 cm proximal to the knee joint line as the cutoff point [7]. Sisto et al [2] included fractures occurring within 15 cm proximal to the knee joint line. For the purposes of this paper, we define a *supracondylar periprosthetic fracture* as one occurring within 15 cm of the joint line or, in the case of a stemmed component, less than 5 cm from the proximal end of the femur.

Treatment of supracondylar periprosthetic fractures includes both nonoperative means (skeletal traction, bracing) and surgery (external fixation, open or closed reduction with internal fixation, revision arthroplasty with or without distal femoral allografts). Supracondylar periprosthetic fracture classification systems—for example, those devised by DiGioia and Rubash [8], Chen et al [5], and Rorabeck and Taylor [9,10] (see Tables 2-4)— are helpful for distinguishing fractures amenable to

Table 1. Neer et al [6] Classification

Type I	Undisplaced (<5 mm displacement and/or <5° angulation)
Type II	Displaced >1 cm
A	With medial femoral shaft displacement
B	With internal femoral shaft displacement
Type III	Displaced and comminuted

nonoperative treatment from those requiring surgery; they do not, however, distinguish among operative treatments.

Surgical repair for these fractures has become more common as the need to mobilize patients soon after injury to limit morbidity and mortality has become better recognized. Several operative treatments have been used to stabilize these special fractures, including but not limited to intramedullary nails placed both retrograde and antegrade, buttress plates, fixed-angle plates, and external fixators. Selection of the appropriate device relies heavily upon the location of the fracture relative to the total knee component. This crucial point is missed by current classification schemes.

For a classification system to be useful, it must be reliable and reproducible, facilitate interaction among medical professionals, and aid in improving conclusions that can be drawn from research. We have created a new classification system for periprosthetic femur fractures that should act as a guide for the treatment of these fractures. The supracondylar periprosthetic femur fracture classification proposed herein is straightforward, consisting of 3 types based on the location of the fracture relative to the femoral component (see Fig. 1) as determined from standard anteroposterior and lateral radiographs.

Materials and Methods

Twelve observers were recruited, 3 each of fellowship-trained trauma specialists, fellowship-trained adult reconstruction specialists, fellowship-trained musculoskeletal radiologists, and orthopaedic residents.

Table 2. DiGioia and Rubash [8] Classification

Group I	Extra-articular, undisplaced (<5 mm displacement or <5° angulation)
Group II	Extra-articular, displaced (>5 mm displacement or >5° angulation)
Group III	Severely displaced (loss of cortical contact) or angulated (>10°); may have intercondylar or T-shaped component

Table 3. Chen et al [5] Classification

Type I	Nondisplaced (Neer type II)
Type II	Displaced and/or comminuted (Neer types II and III)

Initially, observers classified 28 consecutive cases of periprosthetic femur fractures above total knee arthroplasties from good-quality anteroposterior and lateral radiographs collected by the first author (ES, who was not among the observers; cases were excluded in which the knee component was stemmed or had an intercondylar box) according to the new classification system outlined in Fig. 1. Cases were identified from our emergency room logs from 1996 to 2002.

Subsequently, the observers were shown the same 28 radiographs in random order 3 months later. Observers were not initially informed that they were to be retested, and radiographs were made unavailable for review during the 3-month interval. No time limit was allotted for review of the radiographs. No questions were allowed while the radiographs were being reviewed or during the interval between reviewing sessions.

Statistical Analysis

Study results were analyzed using the κ statistic according to standard criteria described by Landis and Koch [11], where 0.00 to 0.20 = slight agreement, 0.21 to 0.40 = fair agreement, 0.41 to 0.60 = moderate agreement, 0.61 to 0.80 = substantial agreement, and 0.81 to 1.00 = almost perfect agreement.

Power analysis of the results was performed for evaluation of intraclass correlation coefficients [12].

Results

Interobserver Reliability

There was perfect agreement among the 4 observer groups for 61% of the fractures (Table 5). The mean reliability coefficient (κ statistic) for orthopaedic trauma specialists was 0.85 (almost perfect

Table 4. Rorabeck and Taylor [10] Classification

Type I	Undisplaced fracture; prosthesis intact
Type II	Displaced fracture; prosthesis intact
Type III	Displaced or undisplaced fracture; prosthesis loose or failing