PERIPROSTHETIC FRACTURES

TOTAL HIP ARTHROPLASTY

Femoral Shaft Fractures

Epidemiology

- **Intraoperative**: There is a 0.3% up to 5% incidence overall, including cemented and uncemented components.
- **Postoperative**: There is a 0.1% incidence.
- They occur more frequently with noncemented components, with an incidence of 2.6% to 5% to as high as 21% for noncemented revisions.
- Mortality associated with age >70 years and male sex (men 2.1% vs. 1.2% in women).

Risk Factors

- **Osteopenia**: Osteoporosis or bone loss secondary to osteolysis
- Rheumatoid arthritis
- Total hip arthroplasty (THA) following failed open reduction and internal fixation (ORIF)
- Stress risers secondary to cortical defects
- Revision surgery
- **Inadequate implant site preparation**: Large implant with inadequate reaming or broaching may be responsible.
- **Pericapsular pathology**: A scarred capsule with inadequate release may result in intraoperative fracture.
- **Loose components**: Loose femoral components are responsible for up to 33% of periprosthetic femur fractures.

Surgical Considerations (to Avoid Periprosthetic Fracture During Revision Surgery)

- Use longer stem prosthesis, spanning twice the bone diameter beyond the defect.
Consider bone grafting the defect.
Consider strut allograft or plate support.
Place cortical windows in an anterolateral location on the femur in line with the neutral bending axis.
Leave cortical windows <30% of the bone diameter.
Choose the correct starting point for reaming and broaching.

**Classification**

*American Academy of Orthopaedic Surgeons Classification (Fig. 6.1)*

This divides the femur into three separate regions:

**Level I:** Proximal femur distally to the lower extent of the lesser trochanter

**Level II:** 10 cm of the femur distal to level I

**Level III:** Covers remainder of femur distal to level II

**Type I:** Fracture proximal to the intertrochanteric line that usually occurs during dislocation of the hip

**Type II:** Vertical or spiral split that does not extend past the lower extent of the lesser trochanter

**Type III:** Vertical or spiral split that extends past the lower extent of the lesser trochanter but not beyond level II, usually at the junction of the middle and distal thirds of the femoral stem

**Type IV:** Fractures that traverse or lie within the area of the femoral stem in level III, with type IVA being a spiral fracture around the tip and type IVB being a simple transverse or short oblique fracture

**Type V:** Severely comminuted fractures around the stem in level III

**Type VI:** Fractures distal to the stem tip, also in level III

Vancouver Classification (Fig. 6.2)

Type A: Fracture in the trochanteric region
  A\(_G\): Greater trochanteric region
  A\(_L\): Lesser trochanteric region

Type B: Around or just distal to the stem
  B\(_1\): Stable prosthesis
  B\(_2\): Unstable prosthesis
  B\(_3\): Unstable prosthesis plus inadequate bone stock

Type C: Well below the stem

Treatment Principles

- Treatment depends on:
  - Location of the fracture
  - Stability of the prosthesis
    - A loose stem should be revised.
  - Bone stock
  - Age and medical condition of the patient
  - Accurate reduction and secure fixation

- Options include:
  - **Nonoperative treatment**: limited weight bearing, brace, cast, or traction
  - ORIF (with plate and screws or cable and/or strut allograft)
  - Revision plus ORIF
Vancouver Type A Fractures
- These are usually stable and minimally displaced.
- ORIF is used to maintain abductor function with wide displacement.
- Revision of acetabular component is indicated with severe polyethylene wear.

Vancouver Type B1 Fractures
- These are usually treated with internal fixation.
- Options for fixation include:
  - Wires or cables
  - Plate and screws and/or cables
  - Open versus percutaneous plate placement
  - Cortical onlay allograft—may or may not incorporate
  - Combination
- Long-term results depend on:
  - Implant alignment
  - Preservation of the periosteal blood supply
  - Adequacy of stress riser augmentation

Vancouver Type B2 Fractures
- Revision arthroplasty and ORIF are used.
- Choice of implant includes:
  - Uncemented prosthesis
    - Extensive coated long-stem curved prosthesis
    - Fluted long-stem prosthesis
    - Modular implants
  - Cemented prosthesis

Vancouver Type B3 Fractures
- No sufficient bone stock supports the revision prosthesis.
- Options include:
  - Proximal femoral reconstruction
    - Composite allograft
    - Scaffold technique
  - Proximal femoral replacement
- Treatment depends on:
  - The age of the patient
  - The severity of the bone defect
  - The functional class of the patient

Vancouver Type C Fractures
- Treat independently of the arthroplasty.
- Use a plate and screws and/or cables, usually without a strut allograft.
- Do not create any new stress riser—bypass stemmed implant.
Acetabular Fractures

- Nondisplaced fractures should be observed and treated with crutches and limited weight bearing. There is a high incidence of late loosening of the acetabular component, requiring revision.
- Fractures are associated intraoperatively with significant underreaming prior to the press fit cup.
- Late fracture is associated with osteolysis or stress shielding.
- Fractures must be assessed for pelvic discontinuity.
- Displaced fractures should be treated by ORIF, and the component should be revised.

TOTAL KNEE ARTHROPLASTY

Supracondylar Femur Fractures

Epidemiology

- The postoperative incidence is 0.3% to 3% in primaries and up to 6.3% in revisions.
- They generally occur within 10 years after surgery, usually secondary to relatively minor trauma.

Risk Factors

Supracondylar fractures after total knee replacement are multifactorial in origin, and risk factors include:

- Osteoporosis
- Preexisting neurologic disease
- Knee stiffness/arthrofibrosis
- Notching of the anterior cortex
  - Biomechanical analysis: 3 mm of anterior notching reduces torsional strength of the femur by 29%.
  - There is a high correlation between notching and supracondylar fractures in patients with rheumatoid arthritis and significant osteopenia.
  - In the absence of significant osteopenia, there is no correlation between notching and supracondylar fractures.
  - If notching $\geq$3 mm is noted intraoperatively, stemmed implant may be considered to avoid.

Classification

Periprosthetic Femur Fractures about Total Knees (Lewis and Rorabeck)

This classification takes into account both fracture displacement and prosthesis stability (Fig. 6.3).

Type I: The fracture is nondisplaced, and the bone–prosthesis interface remains intact.
Type II: The interface remains intact, but the fracture is displaced.
Type III: The patient has a loose or failing prosthesis in the presence of either a displaced or a nondisplaced fracture.

Treatment

Principles

- Anatomic and mechanical alignments are critical.
- Nondisplaced fractures may be treated nonoperatively.
- ORIF is indicated if the alignment is unacceptable by closed means and if bone stock is adequate for fixation devices.
- Immediate prosthetic revision is indicated in selected cases.

Nonoperative Treatment

- Long leg casting or cast bracing for 4 to 8 weeks may be used to treat minimally displaced fractures.

Operative Treatment

- Displaced periprosthetic fractures around a total knee replacement are almost always managed with ORIF because of the difficulties in maintaining acceptable alignment after displacement.
  - A fixed angle plate, locked plate, or retrograde intramedullary (IM) nailing may be used for operative stabilization. (NB: Nonunion rates are reported higher with use of IM nail.)

Primary revision with a stemmed component may be considered if there is involvement of the bone–implant interface and if the prosthesis is loose.

Bone loss may be addressed with autologous grafting.

Cases of severe bone loss, especially in the metaphyseal region, may be addressed with distal femoral replacement with a specialized prosthesis designed for oncologic management.

Acceptable alignment guidelines
- Angulation > 5 to 10 degrees in either plane
- > 5-mm translation
- > 10-degree rotation
- > 1-cm shortening

### Tibial Fractures

#### Risk Factors
- Significant trauma (shaft fractures)
- Tibial component malalignment associated with increased medial plateau stress fractures
- Revision surgery with press-fit stems to bypass a defect
- Loose components and osteolysis
- More common with increase in unicompartmental knee replacement
- Pin site placement

#### Classification

**Periprosthetic Tibial Fractures (Felix et al.)**

**Classification is based on three factors:** location of the fracture, stability of the implant, and whether the fracture occurred intraoperatively or postoperatively (Fig. 6.4)

- **Type I:** Occur in the tibial plateau
- **Type II:** Adjacent to the stem
- **Type III:** Distal to the prosthesis
- **Type IV:** Involve the tubercle

The stability of the implant is then used to classify the fractures further.
- Subtype A is a well-fixed implant.
- Subtype B is loose.
- Subtype C fractures are intraoperative.

#### Treatment

**Nonoperative Treatment**

Closed reduction and cast immobilization may be performed for most tibial shaft fractures after alignment is restored.
Early conversion to a cast brace to preserve knee range of motion is advised.

Operative Treatment
- Periprosthetic tibial fractures not involving the plateau require ORIF if closed reduction and cast immobilization are unsuccessful. Use of locked plating with unicortical screws to avoid the keel has made management easier.
- Type I fractures involving the tibial plateau typically involve the bone–implant interface, necessitating revision of the tibial component.

Patella Fractures

Epidemiology
- The postoperative incidence is 0.3% to 5.4% (reported as high as 21%).

Risk Factors
- Large, central peg component
- Excessive resection of the patella during prosthetic implantation
- Lateral release, with devascularization of the patella
- Malalignment
- Thermal necrosis (secondary to methylmethacrylate)
- Excessive femoral component flexion
**Classification**

*Goldberg*

**Type I:** Fractures not involving cement/implant composite or quadriceps mechanism

**Type II:** Fractures involving cement/implant composite and/or quadriceps mechanism

**Type IIIA:** Inferior pole fractures with patellar ligament disruption

**Type IIIB:** Inferior pole fractures without patellar ligament disruption

**Type IV:** Fracture-dislocations

**Treatment**

*Nonoperative Treatment*

- Fractures without component loosening, extensor mechanism rupture, or malalignment of the implant (type I or IIIB) may be treated nonoperatively (these situations compose the majority of clinical cases).
- The patient may be placed in a knee immobilizer for 4 to 6 weeks, with partial weight bearing on crutches.

*Operative Treatment*

- Indicated for patients with disruption of the extensor mechanism, patellar dislocation, or prosthetic loosening
- Treatment options include
  - **ORIF with revision of the prosthetic patella:** This is indicated for types II, IIIA, and IV fractures.
  - **Fragment excision:** This may be undertaken for small fragments that do not compromise implant stability or patellar tracking.
  - **Patellectomy:** This may be necessary in cases of extensive comminution or devascularization with osteonecrosis.
  - Surgical considerations include adequate medial arthrotomy, adequate lateral release, preservation of the superior lateral geniculate artery, and preservation of the patellar fat pad.

**TOTAL SHOULDER ARTHROPLASTY**

**Epidemiology**

- Periprosthetic fractures of the shoulder complicate approximately 1.6% to 2.4% of cases.

**Risk Factors**

- Excessive reaming of the proximal humerus
- Overimpaction of the humeral component
- Excessive torque placed on the humerus during implant insertion
Classification

University of Texas San Antonio Classification of Periprosthetic Shoulder Fractures (Fig. 6.5)

Type I: Fractures occurring proximal to the tip of the humeral prosthesis

Type II: Fractures occurring in the proximal portion of the humerus with distal extension beyond the tip of the humeral prosthesis

Type III: Fractures occurring entirely distal to the tip of the humeral prosthesis

Type IV: Fractures occurring adjacent to the glenoid prosthesis

Treatment

Controversial: Some advocate nonoperative treatment with surgical intervention indicated for compromise of prosthetic fixation and intraoperative fractures. Others advocate aggressive operative stabilization of all periprosthetic fractures of the shoulder.

Nonoperative Treatment

Closed treatment involves fracture brace, isometric exercises, and early range-of-motion exercises until radiographic evidence of healing.

FIGURE 6.5 Classification of periprosthetic shoulder fractures. Type I: fractures occurring proximal to the tip of the prosthesis. Type II: fractures occurring in the proximal portion of the humerus with distal extension beyond the tip of the prosthesis. Type III: fractures occurring entirely distal to the tip of the prosthesis. Type IV: fractures occurring adjacent to the glenoid prosthesis. (From Bucholz RW, Heckman JD, eds. Rockwood and Green’s Fractures in Adults. 5th ed. Baltimore: Lippincott Williams & Wilkins; 2002:587.)
Operative Treatment

- Primary goals include fracture union, prosthesis stability, and maintenance of motion.
- ORIF may be performed with cerclage wiring and possible bone grafting.
- Revision to a long-stem prosthesis may be required for cases with gross implant loosening.
- Options for postoperative immobilization range from sling immobilization for comfort until range-of-motion exercises can be instituted, to shoulder spica casting for 6 weeks in cases of tenuous fixation.

TOTAL ELBOW ARTHROPLASTY

Epidemiology

- The overall prevalence of periprosthetic fractures about the elbow is 5% to 29%.
- Most fractures are preceded by prosthetic loosening and thinning of the cortices. These occur more commonly in the humerus than in the ulna.

Risk Factors

- Osteoporosis
- Paucity of bone between the medial and lateral columns of the distal humerus
- Abnormal humeral bowing in the sagittal plane
- Size and angulation of the humeral and ulnar medullary canals
- Excessive reaming to accommodate the protheses
- Revision elbow surgery

Classification (Fig. 6.6)

Type I: Fracture of the humerus proximal to the humeral component
Type II: Fracture of the humerus or ulna in any location along the length of the prosthesis
Type III: Fracture of the ulna distal to the ulnar component
Type IV: Fracture of the implant

Treatment

Nonoperative Treatment

- Nondisplaced periprosthetic fractures that do not compromise implant stability may be initially addressed with splinting at 90 degrees and early isometric exercises.
- The splint may then be changed to a fracture brace for 3 to 6 weeks.
Operative Treatment

- Displaced type I or II fractures may be managed with ORIF with cerclage wire fixation or with plates and screws. Alternatively, revision to a long-stem humeral component may be performed, with the component extending at least two diameters proximal to the tip of the implant. Supplemental bone grafting may be used as necessary.
- Type III fractures are usually amenable to cerclage wiring.
- If stable fixation of implant components cannot be obtained, consideration should be given to more constrained prostheses.
- Type IV fractures require component revision.
- Displaced olecranon fractures should be fixed with a tension band and cement.