Geriatric Distal Femur Fracture Management Protocols: Review and Evidence-Based Template

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Objectives: Provide a framework for the development of a “Code Femur” protocol for geriatric distal femur fractures.

Design: Literature Review and Evidence Based Note Templates

Intervention: Distal Femur Fracture Fixation and Medical Management

Main Outcome Measurement: Post Operative Mortality

Results: Geriatric distal femur fractures are increasing among osteoporotic fractures in the rising elderly population. Current hip fracture literature recommends fixation of proximal femur fractures in 24-48 hours to reduce mortality and the literature surrounding distal femur fractures in this population is following a similar trend. The goals of distal femur fracture surgery are early mobilization and fracture stabilization in addition to managing the multiple medical co-morbidities. This review discusses the treatment options available for geriatric distal femur fractures that allow for early mobilization and examines the benefits of early operative care.

Conclusion: Geriatric distal femur fractures present similar challenges to management as geriatric hip fractures and an understanding of medical co-management and early appropriate surgery through the development of a distal femur fracture program similar to those developed for hip fractures warrants consideration.

Level of Evidence: Level IV, Systematic Review

Keywords: Code Femur, Geriatric, Distal Femur Fracture, Post-operative Mortality, Co-Morbidity

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INTRODUCTION

Fractures of the distal femur are common orthopaedic injuries, occurring with an incidence of 37 per 100,000 person-years in the United States[1]. Distal femur fractures (DFF) account for <0.5% of all fractures, and approximately 4-6% of all femoral fractures, as opposed to the 72% and 22% observed in the proximal femur and diaphysis, respectively [2,3]. These injuries follow a bimodal distribution with high energy mechanisms in young adult males and low energy mechanisms in geriatric females with osteoporosis[3].

The incidence of osteoporotic fractures has risen in recent years with aging of the US population. The range of osteoporotic fractures recognized are increasing beyond the traditional vertebral compression, distal humerus, and femoral neck fractures to include fractures about the knee[2]. Considering that geriatric patients tend to have multiple accompanying comorbidities, achieving optimal outcomes in these patients can be difficult. Studies have reported higher rates of in-hospital mortality for geriatric patients burdened with higher scores on the Charlson Comorbidity Index (CCI) [4-6]. Streubel et al. reported 30-day, 6-month, and 1-year mortality rates to be 6%, 18%, and 25%, respectively, in 92 geriatric distal femur fractures patients, with comorbidities significantly increasing the hazard ratios (HR) for mortality, such as congestive heart failure (HR = 4.52), dementia (HR = 4.52), moderate to severe renal disease (HR = 4.67), and history of a malignant tumor (HR = 2.9)[7].

Surgical management has become the preferred treatment strategy for distal femur fractures due to improvements in alignment and functional outcomes over nonsurgical management, although bracing may be sufficient in stable, nondisplaced fractures or for patients who are non-ambulatory or of high surgical risk[8]. However, non-ambulatory patient management has been controversial, as a comparison study conducted found that one-third (4/12) of non-ambulatory patients managed nonoperatively for supracondylar femur fractures had skin or wound complications, and that an additional three patients eventually required above knee amputations. Whereas the 17 patients managed surgically did not have any wound complications and did not require further surgery, increasing support for surgical management even in patients who are nonambulatory[9].

Minimally invasive or open lateral plating, or placement of an intramedullary nail (IMN) are the most common treatments. Alternatively, total knee arthroplasty (TKA) or distal femur replacement (DFR) may be used in patients with osteoarthritis (OA) of the knee, previous arthroplasty, or severely comminuted fractures[6,8].

The use of IMN for distal femur fractures began in the 1980s, as orthopaedic surgeons sought an alternative to open reduction internal fixation (ORIF) due to concerns with soft tissue trauma, periosteal bone stripping, infection rates, and revisions secondary to pseudoarthrosis[10]. Although effective, IMN was historically used for extra-articular fractures, but improvements in techniques, materials and design have led to increased use for intraarticular and comminuted fractures [8,10,11].

This study evaluates the treatment options for distal femur fractures in a geriatric population. The orthopaedic, geriatric medicine, anesthesiology, and medical literature has reported extensively on the benefits of multidisciplinary, expedited comorbidly evaluation,[12,13] and early mobilization benefits of surgical intervention for geriatric proximal femur and hip fractures with hip fracture programs and protocols. The purposes of this study are to review the corollary body of evidence of distal femur fractures and to provide an example note template to facilitate communication among the treatment teams.

METHODS

Literature review was conducted by extracting scientific publications from Pubmed, Embase, Web of Science, and Google Scholar databases. Search terms included a combination of, "geriatric", "distal femur fracture", "supracondylar", "intra-articular", "extra-articular", "Hoffa fracture", "intramedullary nail", "arthroplasty", "management", and "outcomes". Articles included were published in English since the year 2000 and focused on isolated geriatric (patient age ≥65 years old) distal femur fractures. Articles addressing pathologic fractures, polytrauma, or patient populations <65 years old were excluded.

RESULTS

Search yielded a total of 900 publications, of which 799 were published after the year 2000 and in English. 311 articles remained after accounting for geriatric populations, and 93 full-length articles were included after sorting abstracts for relevance, quality, and duplicates.

Osteology and deforming forces

The distal femur encompasses the region from the metaphyseal-diaphyseal junction to the articular surface of the femoral condyles. The femoral shaft is cylindrical in shape, and the condyles are curved, smooth surfaces designed to articulate with the proximal tibia. The distal femur becomes trapezoidal in cross-section towards the articular surface. In the axial plane, the lateral cortex of the femur slopes 10 degrees, and the medial cortex slopes 25 degrees. The medial condyle extends more distally than the lateral condyle, and the posterior halves of both the medial and lateral condyles are posterior to the posterior cortex of the femoral shaft. The femoral shaft, which makes the anatomical axis of the femur is 6-7 degrees valgus from the knee the joint, and 7-11 degrees lateral to the loading axis that runs from the femoral head to middle of the ankle joint[14].

The surrounding musculature is critical in determining the deforming forces in distal femur fractures[14]. Shortening of the fracture with concomitant extension and varus deformity of the distal bone segment is most frequently observed[15]. The hamstrings and quadriceps are responsible for the shortening force, while the adductor muscles account for varus displacement, and gastrocnemius causes extension of the distal fragment and apex posterior angulation or rotation [14,15].

Classification system

Classification of distal femur fractures may be descriptive (e.g., supracondylar, intercondylar, extra-articular, intra-articular), or described by the Orthopaedic Trauma Association (OTA) classification system, with the number "33" indicating the fracture is in the distal femur and the letters A, B, and C specifying extra-articular, unicondylar, and bicondylar, respectively, with an additional numeric signifier 1-3 representing the level of comminution[16].

Presentation

Geriatric patients with distal femur fractures often present after a ground-level fall, in severe pain with impaired weightbearing. Obvious deformity, swelling and bruising may be present, although these findings may be more difficult to observe in an obese population[8]. Clinicians should also be mindful of open fracture, which occurs in 5-10% of supracondylar fractures, with a higher prevalence in high energy, polytrauma patients[17]. Open fracture wounds are most likely to be found on the anterior thigh proximal to the patella[8]. Initial management consists of neurovascular exam pre- and post-reduction, temporary immobilization with splint or knee immobilizer, and consideration of skeletal traction in patients with unstable fracture and limb shortening[8].

Diagnostic Imaging

Imaging in distal femur fractures begins with AP and lateral plain radiographs of the femur, knee and hip[18]. Imaging of the entire femur evaluates for associated injuries and imaging the contralateral femur may be useful for comparison and pre-operative planning[19]. AP, lateral, and oblique traction views with appropriate pain control may provide better visualization if radiographs are obscured by excessive shortening or comminution; however, imaging after external fixation provides the same benefit with less morbidity[14,18].

CT with coronal and sagittal reconstruction is recommended in complex and intra-articular fractures. Nork et al. reported that 38.1% of supracondylar-intercondylar distal femur fractures had concomitant coronal plane fractures; however, plain radiographs identified only 69% (66/95) of coronal plane fragments. Further comparison was made between 102 knees scanned with CT and 100 knees with plain radiographs only, and radiographs identified coronal plane fractures in 29% versus significantly higher sensitivity of CT in detecting coronal plane fractures in 47% of studies[20]. A more recent study found that coronal plane fractures occurred in 53% (29/55) of patients with intercondylar distal femur fractures, furthering support for use of CT to avoid missing Hoffa fractures[21].

Displacement of the distal femur fragment can damage the popliteal artery and lead to neurovascular compromise. Ankle-brachial index (ABI) should be performed if there is concern for vascular injury after standard neurovascular exam and followed up with angiography if ABI < 0.9[19]. An ABI < 0.9 is commonly cited a has having >90% sensitivity and 95% specificity for diminished arterial blood flow; however, in a prospective study of 38 patients Mills et al. found ABI to approach 100% sensitivity, specificity, and positive predictive value for diagnosing vascular injury[22,23].

Associated Injuries

The geriatric population is highly susceptible to "fragility" fractures. These are defined as fractures that occur from "low energy trauma", often a fall from standing height, that would not normally result in a fracture[24]. Fragility fractures affect one in three women and one in five men within their lifetimes. The most common sites of these injuries include the hip, lumbar vertebrae, and distal radius[25]. Geriatric distal femur fractures occur with an incidence of 37 per 100,000 person-years in the United States, significantly lower than the 958/414 (women/men) observed for hip fractures, 1,100/450 (women/men) distal radius fractures, and 3,200/2,500 (women/men) for vertebral fractures per 100,000 person-years[1,26-28]. Fragility fractures can occur concomitantly and additional imaging is indicated for history and exam findings concerning for multiple fragility fractures[19].

Tibial plateau fractures have an incidence of 10.3/100,000 people in the US, with a bimodal distribution that closely matches distal femur fractures incidence. As tibial plateau fractures occur most often secondary to falls in geriatric females, clinicians should be attentive to the possibility of co-existing distal femur fractures and tibial plateau fracture, although data on co-incidence is limited[29,30].

Treatment Options for Distal Femur Fracture
Overview

There are multiple options for the treatment of distal femur fractures in the geriatric patient with retrograde femoral nail, lateral plate, plate-nail hybrid constructs, and dual plate constructs accounting for the majority of management strategies.[31] [32] The overall goals of operative fixation are to restore length, alignment, and rotation to the meta-diaphyseal region and anatomic restoration of the articular block, in addition to construct stability that allows for knee range of motion[33]. Arthroplasty options include acute TKA and DFR.[31,33] External fixator placement is typically reserved for temporizing open fractures or definitive treatment for patients with poor skin that may preclude other methods of fixation acutely. Treatment strategies are evolving with goals of early mobilization and weightbearing. [31]

Non-operative management of geriatric distal femur fractures is rare as there are significant increase in mortality following distal femur fracture with conservative management[34]. Initially, non-operative management was described to have good rates of healing by Neer in 1967 and operative treatment was reserved for cases of nonunion or open fracture[35]. However, as evidence of increased mortality associated with distal femur fractures in the elderly emerged, focus shifted toward fixation[7,34,36,37]. Methods for non-operative treatment have evolved but involve immobilization with protected weightbearing in a hinged knee brace or knee immobilizer with radiographic follow up throughout the healing course[8,31].

Neer initially described treatment with bed rest and traction, whereas modern fractures are typically treated using a knee immobilizer. Patient selection for non-operative treatment is important and should be reserved for patients who are poor surgical candidates or have nondisplaced fractures[8].

Intramedullary Nail

Once reserved for extra-articular fractures, IMN are now being used for intra-articular fractures.[38] Previously, reconstruction of the articular surface was accomplished through multiple independent lag screws or lateral plating in addition to the fixation available through the nail.[38] Retrograde nails have increased in use as load sharing devices allowing for earlier weight bearing in patients who are at increased risk for adverse events associated with prolonged immobilization. Additionally, IMN have been shown to result in union rates that are comparable to plate fixation.[39,40] Nino et al, reported a case series of comminuted distal femur fractures treated with intramedullary nail that had 86% union rates at 3 month follow-up.[41] They also reported minimal complications and the most common reason to return the surgery was for manipulation under anesthesia due to arthrofibrosis of the knee.[41] Wahnert et al examined the biomechanics of retrograde femoral nails and lateral locking plates and found that lateral locking plate alone provided torsional stability but did not provide sufficient support for axial loads, leading to the recommendation that femoral nails should be used for mobile patients due to superior axial loading and range of motion compared to lateral plates. [32] Pekmezci et al examined newer generation nails that allow distal interlocking screws that lock into the nail and compared their fatigue strength to traditional retrograde nails and lateral locking plates finding that locking nails had superior stiffness and fatigue lifespan compared to locking plates and superior fatigue strength compared to traditional retrograde nails.[42]

Lateral Plate Open Reduction Internal Fixation

Lateral plating has been a mainstay of treatment for geriatric distal femurs since operative fixation became standard. Lateral plates provide reliable methods to fix fractures that may not be amenable to intramedullary nail. Traditional methods of plate fixation relied on an extensile lateral approach to access the entire plate; however, minimally invasive techniques have evolved.[43,44] Biomechanical studies have shown that lateral locking plates provide torsional stability to these peri-articular fractures in addition to bridging the metaphysis providing a long working length for the plate reducing the risk of failure [32,45]. Bliemel et al also compared lateral locked plates to intramedullary nail and found no significant difference in axial load to failure.[46] Although lateral plating can now be done through minimally invasive techniques, it is not without complication. The most common complication of lateral locking plate fixation is nonunion with rates reported between 13 and 49%.[33,47,48]

Alternate Constructs for Treatment

Although IMN and lateral plate are the most common constructs for treatment of geriatric distal femur fractures, plate and nail combinations and dual plate constructs have emerged as alternatives. Both constructs were developed with the intention to allow early weight bearing in patients to improve outcomes, specifically in reducing nonunion risk. [49-52] Plate over nail constructs were intended to provide additional rigidity to the articular distal femur fracture, share load through the diaphysis, and avoid dual incisions about the medial and lateral articular surfaces[50,53] Passias et al examined a small cohort of patients that was treated with plate and nail constructs and found 100% union rates.[51] However, there was a significant increase in operative time for the plate nail combination group, but complication rates were comparable. [51]Plate-plate constructs provide similar advantages and nonunion rates as plate-nail combinations. However, plate-plate combinations improve reduction, prevent iatrogenic comminution, and prevent "golf club" deformity. [49] Medda et al and Park et al both examined dual plate constructs and found that the addition of a medial plate in addition to the traditional lateral plate provided a sufficient increase in stability to allow for reliable fracture healing and immediate weightbearing. [49,52] Additionally, Park et al demonstrated an increased load to failure for dual plate constructs as well as lower mean fracture displacement in anatomic models.[52]

Total Knee Arthroplasty and Distal Femoral Replacement

Reports of prolonged immobility, malunion and nonunion, and the need to address complex primary and periprosthetic distal femur fractures led to the use of TKA and DFR for surgical management[54,55]. Although used less frequently than ORIF with plating or IMN, arthroplasty may be beneficial in select patients and can lead to improved short-term outcomes.[54-56] Additionally, arthroplasty has the distinct advantage of not requiring fracture healing and implants that are stable for immediate weightbearing post operatively. [57,58] Current literature has compared functional outcomes and complication rates for patients with comminuted distal femoral fractures for DFR and lateral plating without demonstrating a difference in complication rates or functional outcomes.[57,58] Rubinger et al examined the role of DFR in very distal comminuted fractures and discovered for this subset of fractures that there were significantly lower reoperation rates for DFR compared to surgical fixation.[59] Rosen et al examined a series of distal femur fractures treated with arthroplasty and demonstrated a 71% rate of return to preinjury ambulatory status, with the remaining patients only requiring one additional level of assistance.[60]

Complications

The most frequently reported causes of revision surgeries in distal femur fracture patients include nonunion (4.8%), mechanical failure (3.6%), and deep infection (2.4%), with an overall re-operation rate of 13.4% with either lateral plating or IMN [40]. Factors associated with higher non-union rates are smoking, chronic illness (e.g., diabetes, peripheral artery disease, cancer), chronic NSAID/corticosteroid use, and advanced age [6]. Additional complications such as venous thromboembolism, acute kidney injury, and gastrointestinal bleeding have been reported in geriatric distal femur fracture patients. However, respiratory complications (e.g. pneumonia, respiratory failure), cardiac complications (e.g., MI, CHF), and UTI have been specifically associated with increased one-year mortality rates. Moloney et al. found that up to 37.5% of distal femur fracture patients may experience any one of these complications and 11% two or more complications [61].

Outcomes

Although outcomes vary among the different osteosynthesis approaches, a meta-analysis conducted by Koso et al. found no significant difference in non-union or other complication rates between plates and IMN [6,40]. In the geriatric population, non-union rates are higher in patients aged 60-74 years (36%) than in those age >75 (13%), although this may be accounted for by higher CCI scores in the younger age group [61].

Prognosis

High mortality rates have been observed in DFF fracture patients, with one year mortality rates ranging from 13.4-38% [5,7,34]. Streubel et al demonstrated that there are was no significant difference in mortality rates between hip fractures and distal femur fractures.[7] A retrospective study of 59 geriatric distal femur fracture patients found that CHF, active cancer, and cognitive impairment were independent risk factors for higher mortality rates, supporting the same conclusion reached by Kammerlander et al [5,34]. This same report did not find significant differences in outcomes according to injury mechanism, type of fracture, or type of osteosynthesis, albeit in a relatively small sample size [34]. Kammerlander et al. have also reported no significant differences in outcomes due to osteosynthesis approach [5]. In agreement with these studies, a systematic review of 30 publications conducted by Salazar et al. compared outcomes of surgical fixation (e.g, locking plate, IMN) and primary DFR and found no significant differences in rate of treatment failure nor postoperative knee range of motion[57].

Time to surgery has previously been shown to have positive effect of hip fracture mortality and it has been hypothesized that there is a similar benefit when treating distal femur fractures.[12] Delay to surgery greater than two days has been associated with increased respiratory complications, as well as increased patient mortality as reported by Myers et al. [37,61] Three separate studies that have assessed time to surgery and found it to not significantly impact mortality rates [5,7,34]. However, Kammerlander et al. have hypothesized that the lower one-year mortality rate (18% vs 25%) observed in their report may be accounted for by a shorter time to surgery (1.8 vs 3.7 days) than in patient cohort from Streubel at al[5,7].

Functional recovery was assessed in one retrospective study of 43 patients (mean age of fracture 80 ± 9.3 years, mean follow up 5.3 ± 3 years) found that only 18% of subjects were able to walk unaided, whereas 23% were completely housebound and 26% were unable to participate in any social activity [5]. However, the study authors of this report did not assess the role of physical therapy in patient mobility and function scores.

Restoration of mobility postoperatively in geriatric distal femur fracture patients is particularly challenging as elderly individuals struggle with partial weight-bearing protocols. Thus, these patients benefit from fixation constructs that allow for early weight-bearing (EWB) and rehabilitation [62]. Historically, EWB after distal femur fracture osteosynthesis was avoided due to concerns for fixation failure rates with open reduction [63]. However, limiting weightbearing prolongs dependence on walking aids, time spent in extended care facilities, and is hypothesized to delay the fracture healing-process leading to increased risk of fixation failure [64,65]. A non-randomized comparative study of 51 distal femur fracture patients status-post osteosynthesis with locking plates found no postoperative complications in the EWB group, whereas the weight-bearing restricted group had four episodes of fracture displacement and two implant failures at 12-week follow up (overall incidence 18.7%) [64].

A study of 52 geriatric distal femur fracture patients treated with minimally invasive locked plating and EWB demonstrated that 38 (73%) were able to return to pre-fracture ambulatory status at one-year follow up [65]. A small case series of nine geriatric (mean age 82 years, range 68-90) patients with distal femur interprosthetic fractures furthered support for EBW, as all patients were successfully rehabilitated with retrograde IMN and ORIF followed by EWB and progressive quadriceps strengthening [66].

A systematic review of 508 distal femur fracture patients managed with less invasive surgical stabilization (LISS) plate fixation also supported the use of early range of motion exercises and weight-bearing following surgery. However, data is lacking on the use of braces, casts, or other immobilization aids in these patients, and ongoing research is needed to determine the optimal physiotherapy protocol to improve outcomes in geriatric distal femur fracture patients [67].

DISCUSSION

Trends in Management

A 20-year prospective cohort study found that of 13,337 distal femur fractures, 45% were treated surgically and 55% were managed non-surgically. The three most used surgical techniques recorded for distal femur fractures, were distal femur plating (41.5%: median age 74; 73% female sex), intramedullary nail (22.3%: median age 75; 74% female sex) , and primary arthroplasty (14.1%: median age 68; 74% female sex) [68]. However, data are lacking as to how the rates of usage of these respective techniques has changed with time. More research is needed to provide an accurate assessment of trends in surgical management of geriatric distal femur fractures.

Areas for Improving Outcomes

This review is limited to studies regarding the management of native distal femur fractures. However, studies have shown that patients with TKAs or tibial plateau fractures have similar morbidities, surgical considerations, and delays to ambulation as do distal femur fracture patients [5,8,69-72]. The management of inter- and peri-prosthetic fractures is especially challenging, as there is minimal native bone[73,74]. This leads to numerous technical considerations for fixing fractures or revising TKA components that are beyond the scope of this review. More outcome studies are needed to describe etiologies for DFF prosthetic mechanical failure and joint infection, as both complications are catastrophic to patients and costly to healthcare systems alike [6,40,61].

CONCLUSION

Geriatric distal femur fractures present similar issues to orthopaedic surgeons as the geriatric hip fracture. Geriatric hip fracture programs have emphasized the importance of early fracture care and post-operative mobilization along with medical co-management to reduce mortality rates. Treatment of the geriatric distal femur fractures have many of the same goals, with emergence of fixation methods that allow for early mobilization post-operatively. Additionally, literature is beginning to show mortality benefits to early treatment of distal femur fractures in the elderly. Currently, there are a variety of treatment modalities that provide patients the benefit of early mobilization including IMN, lateral locking plate, hybrid plate-nail or dual plate constructs, and primary TKA or DFR. Geriatric medical co-management, appropriately early surgical intervention, and use of fixation to allow for mobilization are central to hip fracture programs and merit consideration in the treatment of geriatric distal femur fractures.

EVIDENCE BASED TEPLATE- formatted for EPIC

Chief Complaint: {left/right/bilateral} distal femur fracture

Date of Injury: **

Mechanism of Injury: {ground level fall/fall down stairs/fall from bed/**}

History of Present Illness: ** year-old {male/female} sustained a @mechanism of injury@ on @date of injury@ and presented on @TODAY@ for evaluation and treatment. Endorses pain in {left/right/bilateral} {sacrum/buttock/hip/thigh/knee/leg/ankle/foot/**}. {Able/Unable} to ambulate after the injury. There was {no delay/delay of XX days prior to presentation due to**}.
Endorses {left/right/bilateral} upper extremity pain following injury.

Prior ambulation status:
Home: {wheelchair/walker/cane/without assistive devices/**}
Community: {wheelchair/walker/cane/without assistive devices/**}

Prior activity level:
{Sedentary/low demand/recreational} with activities including **

Antecedent hip pain:
{Endorses/Denies} antecedent pain in {left/right/bilateral} hips.

Previous insufficiency fractures:
{vertebrae/sacrum/hip/pubic rami/distal radius/**} on ** and treated with **

Past Medical History:
@PMH@
Past Surgical History:
@PSH@
Medications:
@MEDS@
Allergies:
@ALG@
Social History:
Tobacco:
Alcohol:
Illicit Drugs:
Lives {alone/with family/in supervised home/**}
Medical power of attorney: ** and phone number **
Family History:
@FAMHXNH@

Review of Systems:
CONSTITUTIONAL: Normal except as in HPI
EYES: Normal except as in HPI
HEENT: Normal except as in HPI
RESPIRATORY: Normal except as in HPI
CARDIOVASCULAR: Normal except as in HPI
GASTROINTESTINAL: Normal except as in HPI
GENITOURINARY: Normal except as in HPI
SKIN: Normal except as in HPI
HEMATOLOGIC/LYMPHATIC: Normal except as in HPI
ALLERGIC/IMMUNOLOGIC: Normal except as in HPI
ENDOCRINE: Normal except as in HPI

MUSCULOSKELETAL: Positive per HPI
NEUROLOGICAL: Normal except as in HPI
BEHAVIOR/PSYCH: Normal except as in HPI

Physical Exam:
Vitals:
@VS@
General:
No acute distress
Cardiovascular:
Regular rate and rhythm, warm and well perfused extremities
Pulmonary:
Non-labored breathing

{RIGHT/LEFT} Upper Extremity:
No lacerations, abrasions, or ecchymoses***
Tender to palpation ***
Compartments soft, compressible***
Range of motion: ***
No pain with passive motion of the fingers***
Able to abduct shoulder, flex and extend elbow, wrist, fingers, and thumb, finger abduction and adduction.
SILT axillary, musculocutaneous, median, radial, and ulnar nerve distributions
2+ radial pulse, brisk cap refill <2s

{RIGHT/LEFT} Lower Extremity:
No lacerations, abrasions, or ecchymoses***
No knee effusion
Tender to palpation ***
Compartments soft, compressible ***
No pain with passive motion of the toes
No pain with short arcs
Range of motion: ***
Able to flex and extend hip and knee, plantarflex, dorsiflex, invert, and evert ankle, flex and extend toes
Able to perform straight leg raise
SILT superficial peroneal, deep peroneal, sural, saphenous, and tibial nerve distributions
2+ dorsalis pedis and posterior tibial pulses, brisk cap refill <2s

Gait: {unable/with assistance/independent}

Laboratory:
@BRIEFLAB(HGB,WBC,MONOPERCENT,PLT,CA,BUN,CREAT,GLU,HGBA1C,ALB,CK,INR,APTT,ESR,CRP)@
Imaging:
X-ray:
{pelvis/hip/femur/knee}
CT: (may be indicated after knee immobilizer or knee-spanning extern fixator placement)

Assessment:
@NAME@ is a @AGE@ @SEX@ who presents with ***

Plan:
- Admit to ***.
- Plan for OR (date***) for operative fixation of {left/right} distal femur
- Informed consent obtained by {patient/medical power of attorney}; risks, benefits, and alternatives discussed
- Additional work-up:
  - CBC, BMP, type and screen, PT/INR/PTT
  - EKG, CXR
- Activity: bedrest***; NWB***
- Foley ***
- VTE prophylaxis
- NPO for above
- Anesthesia consult for preoperative risk stratification

REFERENCES

1. Zlowodzki M, Bhandari M, Marek DJ, Cole PA, Kregor PJ. Operative treatment of acute distal femur fractures: systematic review of 2 comparative studies and 45 case series (1989 to 2005). *J Orthop Trauma*. May 2006;20(5):366-71. doi:10.1097/00005131-200605000-00013
2. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury*. Aug 2006;37(8):691-7. doi:10.1016/j.injury.2006.04.130
3. Martinet O, Cordey J, Harder Y, Maier A, Buhler M, Barraud GE. The epidemiology of fractures of the distal femur. *Injury*. Sep 2000;31 Suppl 3:C62-3. doi:10.1016/s0020-1383(00)80034-0
4. Kammerlander C, Gosch M, Kammerlander-Knauer U, Luger TJ, Blauth M, Roth T. Long-term functional outcome in geriatric hip fracture patients. *Arch Orthop Trauma Surg*. Oct 2011;131(10):1435-44. doi:10.1007/s00402-011-1313-6
5. Kammerlander C, Riedmüller P, Gosch M, et al. Functional outcome and mortality in geriatric distal femoral fractures. *Injury*. Jul 2012;43(7):1096-101. doi:10.1016/j.injury.2012.02.014
6. Canton G, Giraldi G, Dussi M, Ratti C, Murena L. Osteoporotic distal femur fractures in the elderly: peculiarities and treatment strategies. *Acta Biomed*. Dec 5 2019;90(12-s):25-32. doi:10.23750/abm.v90i12-S.8958
7. Streubel PN, Ricci WM, Wong A, Gardner MJ. Mortality after distal femur fractures in elderly patients. *Clin Orthop Relat Res*. Apr 2011;469(4):1188-96. doi:10.1007/s11999-010-1530-2
8. Gwathmey FW, Jr., Jones-Quaidoo SM, Kahler D, Hurwitz S, Cui Q. Distal femoral fractures: current concepts. *J Am Acad Orthop Surg*. Oct 2010;18(10):597-607. doi:10.5435/00124635-201010000-00003
9. Cass J, Sems SA. Operative versus nonoperative management of distal femur fracture in myelopathic, nonambulatory patients. *Orthopedics*. Nov 2008;31(11):1091.
10. Seifert J, Stengel D, Matthes G, Hinz P, Ekkernkamp A, Ostermann PA. Retrograde fixation of distal femoral fractures: results using a new nail system. *J Orthop Trauma*. Aug 2003;17(7):488-95. doi:10.1097/00005131-200308000-00003
11. Papadokostakis G, Papakostidis C, Dimitriou R, Giannoudis PV. The role and efficacy of retrograding nailing for the treatment of diaphyseal and distal femoral fractures: a systematic review of the literature. *Injury*. Jul 2005;36(7):813-22. doi:10.1016/j.injury.2004.11.029
12. Investigators HA. Accelerated surgery versus standard care in hip fracture (HIP ATTACK): an international, randomised, controlled trial. *Lancet*. Feb 29 2020;395(10225):698-708. doi:10.1016/S0140-6736(20)30058-1
13. Perry C, Rossettie, S, Hayward, D, Folsom, A, Jacobson, A, Adler, A, Polmear, M Medical Management of Common Comorbidities in Elderly Patients with Proximal Femur Fractures. *Journal of Orthopedic Business*. 2022;2(2):19-36. doi:https://doi.org/10.55576/job.v2i2.17
14. Link BC, Babst R. Current concepts in fractures of the distal femur. *Acta Chir Orthop Traumatol Cech*. 2012;79(1):11-20.
15. Stover M. Distal femoral fractures: current treatment, results and problems. *Injury*. Dec 2001;32 Suppl 3:SC3-13. doi:10.1016/s0020-1383(01)00179-6
16. Meinberg EG, Agel J, Roberts CS, Karam MD, Kellam JF. Fracture and Dislocation Classification Compendium-2018. *J Orthop Trauma*. Jan 2018;32 Suppl 1:S1-S170. doi:10.1097/BOT.0000000000001063
17. Dugan TR, Hubert MG, Siska PA, Pape HC, Tarkin IS. Open supracondylar femur fractures with bone loss in the polytraumatized patient - Timing is everything! *Injury*. Dec 2013;44(12):1826-31. doi:10.1016/j.injury.2013.03.018
18. Gangavalli AK, Nwachuku CO. Management of Distal Femur Fractures in Adults: An Overview of Options. *Orthop Clin North Am*. Jan 2016;47(1):85-96. doi:10.1016/j.ocl.2015.08.011
19. Boyce RH, Singh K, Obremskey WT. Acute Management of Traumatic Knee Dislocations for the Generalist. *J Am Acad Orthop Surg*. Dec 2015;23(12):761-8. doi:10.5435/JAAOS-D-14-00349
20. Nork SE, Segina DN, Aflatoon K, et al. The association between supracondylar-intercondylar distal femoral fractures and coronal plane fractures. *J Bone Joint Surg Am*. Mar 2005;87(3):564-9. doi:10.2106/JBJS.D.01751
21. Richards JA, Berkay FB, Davis CM, Zamora RA. Intra-articular Fracture Pattern in Intercondylar Distal Femur Fractures: An Analysis of Frequency and Major Fracture Fragments. *Injury*. Apr 2021;52(4):967-970. doi:10.1016/j.injury.2020.11.061
22. Khan TH, Farooqui FA, Niazi K. Critical review of the ankle brachial index. *Curr Cardiol Rev*. May 2008;4(2):101-6. doi:10.2174/157340308784245810
23. Mills WJ, Barei DP, McNair P. The value of the ankle-brachial index for diagnosing arterial injury after knee dislocation: a prospective study. *J Trauma*. Jun 2004;56(6):1261-5. doi:10.1097/01.ta.0000068995.63201.0b
24. Kanis JA, Oden A, Johnell O, Jonsson B, de Laet C, Dawson A. The burden of osteoporotic fractures: a method for setting intervention thresholds. *Osteoporos Int*. 2001;12(5):417-27. doi:10.1007/s001980170112
25. Hernlund E, Svedbom A, Ivergard M, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Arch Osteoporos*. 2013;8:136. doi:10.1007/s11657-013-0136-1
26. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. *JAMA*. Oct 14 2009;302(14):1573-9. doi:10.1001/jama.2009.1462
27. Nellans KW, Kowalski E, Chung KC. The epidemiology of distal radius fractures. *Hand Clin*. May 2012;28(2):113-25. doi:10.1016/j.hcl.2012.02.001
28. Schousboe JT. Epidemiology of Vertebral Fractures. *J Clin Densitom*. Jan-Mar 2016;19(1):8-22. doi:10.1016/j.jocd.2015.08.004
29. Elsoe R, Larsen P, Nielsen NP, Swenne J, Rasmussen S, Ostgaard SE. Population-Based Epidemiology of Tibial Plateau Fractures. *Orthopedics*. Sep 2015;38(9):e780-6. doi:10.3928/01477447-20150902-55

30. Elsoe R, Ceccotti AA, Larsen P. Population-based epidemiology and incidence of distal femur fractures. *Int Orthop*. Jan 2018;42(1):191-196. doi:10.1007/s00264-017-3665-1
31. Hake ME, Davis ME, Perdue AM, Goulet JA. Modern Implant Options for the Treatment of Distal Femur Fractures. *J Am Acad Orthop Surg*. Oct 1 2019;27(19):e867-e875. doi:10.5435/JAAOS-D-17-00706
32. Wahnert D, Hoffmeier K, Frober R, Hofmann GO, Muckley T. Distal femur fractures of the elderly--different treatment options in a biomechanical comparison. *Injury*. Jul 2011;42(7):655-9. doi:10.1016/j.injury.2010.09.009
33. von Keudell A, Shoji K, Nasr M, Lucas R, Dolan R, Weaver MJ. Treatment Options for Distal Femur Fractures. *J Orthop Trauma*. Aug 2016;30 Suppl 2:S25-7. doi:10.1097/BOT.0000000000000621
34. Merino-Rueda LR, Rubio-Saez I, Mills S, Rubio-Suarez JC. Mortality after distal femur fractures in the elderly. *Injury*. Jul 2021;52 Suppl 4:S71-S75. doi:10.1016/j.injury.2021.03.066
35. Neer CS, 2nd, Grantham SA, Shelton ML. Supracondylar fracture of the adult femur. A study of one hundred and ten cases. *J Bone Joint Surg Am*. Jun 1967;49(4):591-613.
36. Jennison T, Divekar M. Geriatric distal femoral fractures: A retrospective study of 30 day mortality. *Injury*. Feb 2019;50(2):444-447. doi:10.1016/j.injury.2018.10.035
37. Myers P, Laboe P, Johnson KJ, et al. Patient Mortality in Geriatric Distal Femur Fractures. *J Orthop Trauma*. Mar 2018;32(3):111-115. doi:10.1097/BOT.0000000000001078
38. Langford J, Burgess A. Nailing of proximal and distal fractures of the femur: limitations and techniques. *J Orthop Trauma*. May-Jun 2009;23(5 Suppl):S22-5. doi:10.1097/BOT.0b013e31819f2797
39. Shah JK, Szukics P, Gianakos AL, Liporace FA, Yoon RS. Equivalent union rates between intramedullary nail and locked plate fixation for distal femur periprosthetic fractures - a systematic review. *Injury*. Apr 2020;51(4):1062-1068. doi:10.1016/j.injury.2020.02.043
40. Koso RE, Terhoeve C, Steen RG, Zura R. Healing, nonunion, and re-operation after internal fixation of diaphyseal and distal femoral fractures: a systematic review and meta-analysis. *Int Orthop*. Nov 2018;42(11):2675-2683. doi:10.1007/s00264-018-3864-4
41. Nino S, Parry JA, Avilucea FR, Haidukewych GJ, Langford JR. Retrograde intramedullary nailing of comminuted intra-articular distal femur fractures results in high union rate. *Eur J Orthop Surg Traumatol*. Oct 8 2021;doi:10.1007/s00590-021-03140-8
42. Pekmezci M, McDonald E, Buckley J, Kandemir U. Retrograde intramedullary nails with distal screws locked to the nail have higher fatigue strength than locking plates in the treatment of supracondylar femoral fractures: A cadaver-based laboratory investigation. *Bone Joint J*. Jan 2014;96-B(1):114-21. doi:10.1302/0301-620X.96B1.31135
43. Schutz M, Muller M, Krettek C, et al. Minimally invasive fracture stabilization of distal femoral fractures with the LISS: a prospective multicenter study. Results of a clinical study with special emphasis on difficult cases. *Injury*. Dec 2001;32 Suppl 3:SC48-54. doi:10.1016/s0020-1383(01)00183-8
44. Krettek C, Muller M, Miclau T. Evolution of minimally invasive plate osteosynthesis (MIPO) in the femur. *Injury*. Dec 2001;32 Suppl 3:SC14-23. doi:10.1016/s0020-1383(01)00180-2
45. Ricci WM, Streubel PN, Morshed S, Collinge CA, Nork SE, Gardner MJ. Risk factors for failure of locked plate fixation of distal femur fractures: an analysis of 335 cases. *J Orthop Trauma*. Feb 2014;28(2):83-9. doi:10.1097/BOT.0b013e31829e6dd0
46. Bliemel C, Buecking B, Mueller T, et al. Distal femoral fractures in the elderly: biomechanical analysis of a polyaxial angle-stable locking plate versus a retrograde intramedullary nail in a human cadaveric bone model. *Arch Orthop Trauma Surg*. Jan 2015;135(1):49-58. doi:10.1007/s00402-014-2111-8
47. Bologna MG, Claudio MG, Shields KJ, Katz C, Salopek T, Westrick ER. Dual plate fixation results in improved union rates in comminuted distal femur fractures compared to single plate fixation. *J Orthop*. Mar-Apr 2020;18:76-79. doi:10.1016/j.jor.2019.09.022
48. Rodriguez EK, Zurakowski D, Herder L, et al. Mechanical Construct Characteristics Predisposing to Non-union After Locked Lateral Plating of Distal Femur Fractures. *J Orthop Trauma*. Aug 2016;30(8):403-8. doi:10.1097/BOT.0000000000000593
49. Medda S, Kessler RB, Halvorson JJ, Pilson HT, Babcock S, Carroll EA. Technical Trick: Dual Plate Fixation of Periprosthetic Distal Femur Fractures. *J Orthop Trauma*. Apr 1 2021;35(4):e148-e152. doi:10.1097/BOT.0000000000001869
50. Liporace FA, Yoon RS. Nail Plate Combination Technique for Native and Periprosthetic Distal Femur Fractures. *J Orthop Trauma*. Feb 2019;33(2):e64-e68. doi:10.1097/BOT.0000000000001332
51. Passias BJ, Emmer TC, Sullivan BD, et al. Treatment of Distal Femur Fractures with a Combined Nail-Plate Construct: Techniques and Outcomes. *J Long Term Eff Med Implants*. 2021;31(3):15-26. doi:10.1615/JLongTermEffMedImplants.2021038016
52. Park KH, Oh CW, Park IH, Kim JW, Lee JH, Kim HJ. Additional fixation of medial plate over the unstable lateral locked plating of distal femur fractures: A biomechanical study. *Injury*. Oct 2019;50(10):1593-1598. doi:10.1016/j.injury.2019.06.032
53. Liporace FA, Aneja A, Carroll EA, Yoon RS. Maintaining the Neutral Axis in the Treatment of Distal Femur Fractures Via Dual Plate or Nail Plate Combination Technique: When and How? *J Orthop Trauma*. Oct 1 2021;35(Suppl 5):S38-S40. doi:10.1097/BOT.0000000000002235
54. Wyles CC, Tibbo ME, Yuan BJ, Trousdale RT, Berry DJ, Abdel MP. Long-Term Results of Total Knee Arthroplasty with Contemporary Distal Femoral Replacement. *J Bone Joint Surg Am*. Jan 2 2020;102(1):45-51. doi:10.2106/JBJS.19.00489
55. Chen F, Li R, Lall A, Schwechter EM. Primary Total Knee Arthroplasty for Distal Femur Fractures: A Systematic Review of Indications, Implants, Techniques, and Results. *Am J Orthop (Belle Mead NJ)*. May/Jun 2017;46(3):E163-e171.

56. Hart GP, Kneisl JS, Springer BD, Patt JC, Karunakar MA. Open Reduction vs Distal Femoral Replacement Arthroplasty for Comminuted Distal Femur Fractures in the Patients 70 Years and Older. *J Arthroplasty*. Jan 2017;32(1):202-206. doi:10.1016/j.arth.2016.06.006
57. Salazar BP, Babian AR, DeBaun MR, et al. Distal Femur Replacement Versus Surgical Fixation for the Treatment of Geriatric Distal Femur Fractures: A Systematic Review. *J Orthop Trauma*. Jan 1 2021;35(1):2-9. doi:10.1097/BOT.0000000000001867
58. Wadhwa H, Salazar BP, Goodnough LH, et al. Distal Femur Replacement Versus Open Reduction and Internal Fixation for Treatment of Periprosthetic Distal Femur Fractures: A Systematic Review and Meta-Analysis. *J Orthop Trauma*. Jan 1 2022;36(1):1-6. doi:10.1097/BOT.0000000000002141
59. Rubinger L, Khalik HA, Gazendam A, et al. Very Distal Femoral Periprosthetic Fractures: Replacement Versus Fixation: A Systematic Review. *J Orthop Trauma*. Nov 1 2021;35(11):573-583. doi:10.1097/BOT.0000000000002080
60. Rosen AL, Strauss E. Primary total knee arthroplasty for complex distal femur fractures in elderly patients. *Clin Orthop Relat Res*. Aug 2004;(425):101-5. doi:10.1097/01.blo.0000132466.65220.62
61. Moloney GB, Pan T, Van Eck CF, Patel D, Tarkin I. Geriatric distal femur fracture: Are we underestimating the rate of local and systemic complications? *Injury*. Aug 2016;47(8):1732-6. doi:10.1016/j.injury.2016.05.024
62. von Rüden C, Augat P. Failure of fracture fixation in osteoporotic bone. *Injury*. Jun 2016;47 Suppl 2:S3-s10. doi:10.1016/s0020-1383(16)47002-6
63. Ebraheim NA, Liu J, Hashmi SZ, Sochacki KR, Moral MZ, Hirschfeld AG. High complication rate in locking plate fixation of lower periprosthetic distal femur fractures in patients with total knee arthroplasties. *J Arthroplasty*. May 2012;27(5):809-13. doi:10.1016/j.arth.2011.08.007
64. Consigliere P, Iliopoulos E, Ads T, Trompeter A. Early versus delayed weight bearing after surgical fixation of distal femur fractures: a non-randomized comparative study. *Eur J Orthop Surg Traumatol*. Dec 2019;29(8):1789-1794. doi:10.1007/s00590-019-02486-4
65. Smith WR, Stoneback JW, Morgan SJ, Stahel PF. Is immediate weight bearing safe for periprosthetic distal femur fractures treated by locked plating? A feasibility study in 52 consecutive patients. *Patient Saf Surg*. 2016;10:26. doi:10.1186/s13037-016-0114-9
66. Hussain MS, Dailey SK, Avilucea FR. Stable Fixation and Immediate Weight-Bearing After Combined Retrograde Intramedullary Nailing and Open Reduction Internal Fixation of Noncomminuted Distal Interprosthetic Femur Fractures. *J Orthop Trauma*. Jun 2018;32(6):e237-e240. doi:10.1097/bot.0000000000001154
67. Smith TO, Hedges C, MacNair R, Schankat K. Early rehabilitation following less invasive surgical stabilisation plate fixation for distal femoral fractures. *Physiotherapy*. Jun 2009;95(2):61-75. doi:10.1016/j.physio.2009.02.002
68. Vestergaard V, Pedersen AB, Tengberg PT, Troelsen A, Schrøder HM. 20-year trends of distal femoral, patellar, and proximal tibial fractures: a Danish nationwide cohort study of 60,823 patients. *Acta Orthop*. Feb 2020;91(1):109-114. doi:10.1080/17453674.2019.1698148
69. Delanois RE, Mistry JB, Gwam CU, Mohamed NS, Choksi US, Mont MA. Current Epidemiology of Revision Total Knee Arthroplasty in the United States. *J Arthroplasty*. Sep 2017;32(9):2663-2668. doi:10.1016/j.arth.2017.03.066
70. Singleton N, Sahakian V, Muir D. Outcome After Tibial Plateau Fracture: How Important Is Restoration of Articular Congruity? *J Orthop Trauma*. Mar 2017;31(3):158-163. doi:10.1097/bot.0000000000000762
71. Pua YH, Poon CL, Seah FJ, et al. Predicting individual knee range of motion, knee pain, and walking limitation outcomes following total knee arthroplasty. *Acta Orthop*. Apr 2019;90(2):179-186. doi:10.1080/17453674.2018.1560647
72. Jiwanlal A, Jeray KJ. Outcome of Posterior Tibial Plateau Fixation. *J Knee Surg*. Jan 2016;29(1):34-9. doi:10.1055/s-0035-1564729
73. Canton G, Tomic M, Giunta M, Maritan G, Murena L. Distal femur periprosthetic knee fractures in elderly patients: clinical and radiographic outcome after internal fixation. *Acta Biomed*. Jul 26 2021;92(S3):e2021028. doi:10.23750/abm.v92iS3.11770
74. Mamczak CN, Gardner MJ, Bolhofner B, Borrelli J, Jr., Streubel PN, Ricci WM. Interprosthetic femoral fractures. *J Orthop Trauma*. Dec 2010;24(12):740-4. doi:10.1097/BOT.0b013e3181d73508