Operative Management of Geriatric Hip Fractures An Evidence-Based Note Template

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Objectives: Provide a framework for the surgical treatment of patients with proximal femur fractures.

Design: Literature review.

Main outcome measurement: Review of evidence-based surgical techniques for specific hip fracture patterns.

Results: Proximal femur fractures are common orthopaedic injuries in the geriatric population, and are subcategorized into femoral neck, intertrochanteric, and subtrochanteric hip fractures. Non-operative management is rare in all types. Femoral neck fractures are treated with either internal fixation or arthroplasty. Internal fixation remains a viable form of fixation in particular patient subgroups and is often driven by fracture patterns. Controversy continues regarding Total Hip Arthroplasty (THA) versus Hemi Hip Arthroplasty (HA). The main factor in the decision to proceed with THA is the pre-injury functional level of the patient, though no clear consensus has been reached as to precise definitions of functionality or thresholds for chronologic age. The choice of implant for treatment of intertrochanteric hip fractures is determined by fracture stability. Stable fracture patterns may be treated by either a sliding hip screw (SHS) or cephalomedullary nail (CMN), with no current difference in total associated cost. Intramedullary nails remain the gold standard and mainstay of treatment of subtrochanteric hip fractures.

Conclusions: A thorough understanding of the differences in operative management of geriatric hip fractures may help orthopedic surgeons optimize patient outcomes as well as minimize health care costs related to implant choice.

Level of Evidence: IV, systematic review

Keywords: Hip Fracture, Operative Management, Surgical technique, Geriatrics, Fragility fracture, Femoral neck fracture, Intertrochanteric hip fracture, Subtrochanteric hip fracture, Hemi Hip Arthroplasty, Total Hip Arthroplasty, Sliding hip screw, cannulated screw fixation, Cephalomedullary nail, Intramedullary nail

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INTRODUCTION

Geriatric hip fractures are morbid injuries with associated mortality and global healthcare burden. Unlike high-energy traumatic fractures in younger patients, geriatric fractures often occur during a low-energy fall. Elderly patients can experience impaired mobility, vision, and cognition which may compromise balance and strength leading to falls.[1] Fractures are common in the hip because it is often involved in pathologies of decreased bone mineral density.[2,3] Worsening neuromuscular function can result in muscle co-contraction preventing natural recovery mechanisms and increasing impact forces rather than absorbing them.[4]

The annual incidence of hip fractures approaches a quarter million injuries, of which approximately half of all involve the femoral neck. Seventy-five percent of femoral neck fractures (FNF) occur in women with an average age of 72 years.[5] Intertrochanteric hip fractures account for 38-50% and also occur more commonly in females.[6] The incidence of intertrochanteric fractures is approximately 63 women and 34 men per 100,000 person-years.[7] Subtrochanteric femur fractures account for 7-34% of femur fractures with a bimodal age distribution.[8]

Trends in preferred intervention for hip fractures have evolved. Cephalomedullary nails (CMN) have largely replaced dynamic hip screws (DHS). The American Board of Orthopaedic Surgery (ABOS) Part II database indicated a trend in recent graduates favoring cephalomedullary nails for intertrochanteric fractures.[9] National registries in Ireland and Sweden revealed decreasing use of DHS.[10,11] Arthroplasty has become more prevalent for femoral neck fractures (FNF), and the percentage increase of total hip arthroplasty (THA) outpaces hemiarthroplasty (HA).[11] Although the overall incidence of femoral neck fractures in the United States decreased by 25% between 2003 and 2013, over the same period THA use increased while HA decreased, and was implemented in younger patients.[12] Management of geriatric hip fracture patients has also evolved as a dedicated orthogeriatric approach has been shown to decrease mortality, length of stay, and overall cost.[13-16]

METHODS

A literature review of Pubmed, Web of Science, and Embase from 2000 to 2020, with the search queries “fracture” AND “hip” OR “femoral neck” OR “intertrochanteric” OR “subtrochanteric” OR “subcapital” OR “transcervical” OR “basicervical” was performed according to PRISMA guidelines.[17] In total 1,471 articles were identified. After filtering for duplicates and full-text availability, 1,402 articles remained and were reviewed by title and abstract. Articles not focused on geriatric hip fractures were eliminated. The reference sections of included articles were utilized to identify additional relevant studies.

Clinical practice guidelines were reviewed from organizations including the American Academy of Orthopaedic Surgeons (AAOS), American Geriatrics Society, British Orthopedic Association (BOA), Eastern Association for the Surgery of Trauma (EAST), National Health Services (NHS), National Institute for Health and Care Excellence (NICE), and Orthopaedic Trauma Association (OTA). The following evidence informs the treatment of geriatric hip fractures.

RESULTS

Osteology and blood supply:

The osteology of the proximal femur has implications for healing potential and fixation techniques of geriatric fractures. The location of the fracture relative to the articular capsule is relevant, as intracapsular fractures (subcapital, transcervical, and basicervical) occur in a zone of minimal periosteum with impaired healing compared to extracapsular fractures. Intracapsular fracture healing is further inhibited by the presence of synovial fluid.[18,19] Intracapsular fractures also threaten the tenuous blood supply to the femoral head. The adult femoral head is predominantly supplied by the medial femoral circumflex artery, although some anatomic variants have a dominant inferior gluteal artery.[20] Any displacement of a femoral neck fracture can disrupt this nearly solitary blood supply and risk femoral head osteonecrosis.[21] Basicervical fractures occur at the base of the femoral neck medial to the intertrochanteric line and proximal to the lesser trochanter.[22] Treatment options included arthroplasty, cannulated screws, sliding hip screws, and cephalomedullary nails. The latter two constitute the most studied implants with similar mortality, major complications, reoperation, and readmission rates.[23,24]

Extracapsular fractures (intertrochanteric and subtrochanteric) can include the dense calcar on the posteromedial aspect of the proximal femur, which results in an unstable pattern with minimal weight-bearing potential. The involvement of the lateral wall is prohibitive to the use of an extramedullary device, as it relies on an intact lateral wall to create compressive forces across the fracture site.

Intertrochanteric hip fractures occur when the fracture is between the greater and lesser trochanters. Intertrochanteric fractures have higher union rates and lower incidence of osteonecrosis compared to femoral neck fractures due to the abundant vascular supply of the metaphyseal region of the femur.[25] The subtrochanteric region is the area below the lesser trochanter extending 5 centimeters distal.[26] Fractures with subtrochanteric extension present with characteristic deforming forces causing the proximal fragment to be flexed, abducted, and externally rotated due to the iliopsoas, gluteal muscles, and short external rotators, respectively. The distal fragment is acted upon by the adductors which cause the segment to be shortened and adducted.

Femoral neck fractures are most commonly classified according to the Garden and Pauwels classification systems. The Garden classification categorizes fractures based on the degree of displacement. In contrast, the Pauwels classification depends on the verticality of the fracture orientation, indicating variable amounts of compressive and shear forces at the fracture site.[27,28] The modified Garden classification simplifies fracture patterns to displaced or non-displaced, which when used as a surrogate for the integrity of the blood supply to the femoral head, it can be used to support the use of arthroplasty for displaced femoral neck fractures to mitigate the risk of osteonecrosis. The stability conferred by a valgus impacted Garden I femoral neck fracture factors into operative decision-making, as the fracture pattern is inherently more stable. This stability is secondary to the valgus orientation of the fracture across the femoral neck, which creates a relative increase in compressive force compared to shear force across the fracture, allowing for less reliance on internal fixation. The opposite of which would be true for a varus impacted femoral neck fracture.

Intertrochanteric fractures have been classified by Evans but characterizing the fracture as stable or unstable is more useful in guiding treatment.[29] Stability is based on several factors, including the integrity of the posteromedial cortex or calcar.[21,29] Displacement of the lesser trochanter can also suggest a large posteromedial fragment, which infers a lack of stability. Reverse obliquity fractures denote an oblique fracture line extending from the medial cortex both laterally and distally, which are inherently unstable and impact the efficacy of extramedullary fixation.

Subtrochanteric fractures are commonly described using the Russel-Taylor classification, which specifies both involvement of the piriformis fossa and the lesser trochanter.[30] These structures are relevant to intramedullary nail insertion and overall stability, respectively. Although pathologic fractures are outside the scope of the present study, it is important to recognize that metastasis to the lesser trochanter predisposes to subtrochanteric fracture and that bisphosphonate use can lead to atypical transverse subtrochanteric fracture.[31,32]

Diagnostic imaging:

Standard diagnostic imaging for geriatric hip fracture includes an AP pelvis, and AP and lateral of the hip, femur, and knee. One study recommended the routine addition of a physician-assisted traction-internal rotation view of the hip based on a change of orthopedic junior resident diagnosis 8.1% of the time and 50% of those new diagnoses required a change to the operative plan.[33] In geriatric patients with ambiguous radiographs and suspicion of an occult hip fracture, T1-weighted coronal sequence on MRI is optimal, with fine-cut CT as a reasonable alternative.[34] Isolated greater trochanteric fracture should also raise suspicion of extension into the intertrochanteric region, confirmed in as many as 90% on MRI.[35] Patients who have delayed presentation (two or more days) after hip fracture have a significantly higher incidence of deep vein thrombosis and should be screened via duplex ultrasound.[36]

Treatment:

Non-operative

Indications for non-operative management of geriatric femoral neck fractures are limited. Non-ambulatory patients at high surgical risk due to unmanageable co-morbidities can be considered for non-operative management.[37] A recent retrospective study found that 3.2% of patients with femoral neck fractures were treated non-operatively within their cohort of 3132 patients. Of these patients, those with low-grade injuries (Garden I or II) and were able to comfortably ambulate at presentation, 82% of them succeeded in avoiding subsequent surgery.[38] An older prospective study found that non-operatively treated valgus impacted femoral neck fractures (Garden I) had no increased morbidity or mortality if ambulation occurred within a few days of admission. Furthermore, 69% achieved union without delayed operation. Of those within the delayed operation group, no difference in morbidity or mortality was reported.[39] However, more recent literature has clearly demonstrated the mortality benefits of acutely fixing geriatric hip fractures.[37] Intertrochanteric and subtrochanteric femur fractures almost exclusively require operative management.[40,41]

Operative Interventions – Femoral Neck

Cannulated screws

Nondisplaced geriatric femoral neck fractures (Garden I or II) have been indicated for cannulated screw fixation (CSFN).[42] Closed reduction and percutaneous CSFN is the least invasive surgical intervention with typically shorter operation times and has been considered sufficient for most stable fracture patterns.[5] This theoretically minimizes blood loss and associated risks in patients with relevant comorbidities. Although cannulated screws have been utilized for displaced femoral neck fractures in younger patients, most modern literature advocates for arthroplasty in geriatric patients with displaced fractures.[42-45] A Cochrane systematic review in 2006 evaluated internal fixation compared to arthroplasty in both nondisplaced and displaced femoral neck fractures. They reported CSFN produced less surgical trauma, though more complications in healing, increased reoperation rates, and equivalent mortality risk.[46] Non-ambulating patients with any Garden classification who are considered high-risk could be indicated for in-situ CSFN to minimize pain during transfers while mitigating operative risk.[47]

Studies have identified several techniques for optimizing CSFN outcomes. Biomechanical studies have shown the addition of a third screw significantly increases resistance to anterior loading, decreases femoral head displacement, and reduces gapping, while an inverted triangle configuration with the most distal screw adjacent to the calcar is the strongest construct.[48,49] A randomized controlled trial found improved radiological union rates at three months in femoral neck fractures treated with two cannulated screws compared to three screws, but the median age was 36 and likely not generalizable to the geriatric population.[50]

Ensuring a distal starting point cephalad to the lesser trochanter prevents iatrogenic fracture during cannulated screw placement.[45] A retrospective study found that increased lateral spread of cannulated screws resulted in statistically significant lower rates of nonunion in displaced FNF.[51] A recent retrospective cohort study of displaced femoral neck fractures found a higher cut-out rate for headless compression screws compared to traditional partially threaded screws and discouraged the use of headless compression screws.[52]

The evidence supporting cannulated screws compared to other interventions for nondisplaced femoral neck fractures is modest. One randomized controlled trial compared hemiarthroplasty to cannulated screws in nondisplaced fractures and found hemiarthroplasty was not superior in functional outcomes as measured by the Harris Hip Score (HHS), but did have improved mobility measured by the timed up-and-go test, as well as fewer major reoperations.[53] Another prospective study in Norway found that displaced FNF treated with HA compared to nondisplaced FNF treated with two cannulated screws had statistically significant lower reoperation rates. Additionally, they found lower pain scores, higher satisfaction rates, and higher quality of life though all were clinically insignificant. FNF treated with cannulated screws had one-year implant survival rates of 89% and 79% for nondisplaced and displaced fractures, respectively.[54]

A recent retrospective study of German registry data found nondisplaced FNF treated with internal fixation had superior mobility at 120 days compared to HA, but the internal fixation cohort only contained about 40% cannulated screws.[55] A randomized controlled trial comparing two cannulated screws to arthroplasty found inferior function scores, higher complication rates, and higher reoperation rates in the cannulated screw group.[56]

Complication rates for cannulated screw fixation are significant. One systematic review found nondisplaced FNF treated with internal fixation had a nonunion rate of 39.2%, an osteonecrosis rate of 31.9%, a reoperation rate attributable to surgical complications of 15.2%, and a revision to HA rate of 12.4%.[43] Another systematic review reported one-year mortality rates between 19-22%, similar reoperation rates of 8-19%, and similar conversion to HA rates of 8-16%.[57] For displaced FNF treated with internal fixation, other studies report the incidence of femoral head avascular necrosis between 30-45%.[42]

Sliding hip compression screw

An alternative to cannulated screw fixation for nondisplaced FNF is a sliding hip compression screw (SHS), which combines femoral neck fixation with an integrated lateral side plate device. Fractures with a more vertical orientation may be better treated with a SHS.[45] The extramedullary nature of the lateral side plate mandates that the lateral wall be intact, otherwise, the SHS is contraindicated.[58,59]

The placement of a SHS is an open procedure with associated increases in dissection and blood loss. The ability of the screw to slide within the plate while maintaining angulation creates compression at the fracture site with physiologic loading. A biomechanical study comparing SHS to CSFN demonstrated less femoral head displacement and greater load to failure with SHS.[60] However, a Cochrane review comparing the interventions found no difference in complications or outcomes, with increased operative time and blood loss for SHS. They declined to make a recommendation between the interventions based on available randomized controlled trials in 2001.[61]

A properly placed SHS should have a tip-to-apex distance less than 25 mm, similar to an intramedullary nail for extracapsular fracture, though some debate has occurred regarding the relative importance of tip-to-apex distance versus inferior lag screw placement within the calcar for intramedullary nails.[62-66] It has been hypothesized that excessive torque and rotation of the femoral head during placement of the larger diameter SHS may increase the risk of osteonecrosis.[5] This can be mitigated by first placing an anti-rotational cannulated screw superior to the intended SHS trajectory, but a biomechanical study determined the additional screw does not improve fracture fixation.[67]

The highest quality studies investigating SHS include both nondisplaced and displaced FNF. The Fixation using Alternative Implants for the Treatment of Hip Fractures (FAITH) study was a randomized controlled trial comparing SHS to two or more cannulated screws for all FNF types.[68] SHS was shown to be equivalent to cannulated screws for reoperation rate, with higher rates of avascular necrosis and conversion to total arthroplasty. Subgroup analysis suggested SHS may be better for smokers, displaced fractures, and basicervical fractures, but the investigators recommended further trials before establishing firm guidelines.

Practice patterns have shifted away from use of the SHS, particularly for displaced FNF as newer evidence supports primary arthroplasty. Previous meta-analysis comparing displaced FNF treated with SHS, cannulated screws, or arthroplasty found decreased mortality risk when SHS was compared to arthroplasty, but not when compared to cannulated screws. Overall, arthroplasty had reduced reoperation rates but greater infection rates, blood loss, and operative time.[69] One exception to the trend of equivalency between internal fixation methods is a prospective study including both displaced and nondisplaced FNF which found better stabilization and earlier mobilization with SHS, with similar duration of surgery and blood loss.[70]

Complication rates for SHS have been found to be similar to cannulated screws. A randomized controlled trial ran concurrently with the FAITH trial found a median femoral neck shortening of 1.1 cm after internal fixation for displaced or nondisplaced FNF. The femoral neck shortening resulted in 40% of patients complaining of leg-length discrepancy and 30% requiring a heel lift. Patients with shortening had statistically significant impaired gait velocities, which was associated with worse function scores.[71]

Arthroplasty

Hemiarthroplasty is indicated for displaced FNF (Garden III or IV) in patients in whom total hip arthroplasty is not deemed necessarily beneficial. These patients are typically characterized as frail, physiologically older, cognitively impaired, or having a limited ambulatory status at baseline.[72] Patients unable to comply with hip precautions due to mental status are typically indicated for HA instead of THA, as HA has demonstrated a lower risk of dislocation.[45] One relative indication of THA over HA is symptomatic osteoarthritis of the hip preceding the injury, due to degenerative changes in the acetabulum.[73] Arthroplasty use for FNF is increasing, with some recommending primary arthroplasty even for nondisplaced fractures. One randomized controlled trial compared HA to CSFN and found improved mobility, fewer major reoperations with HA, but equivalent Harris hip scores.[53]

The indications for THA for FNF have expanded as more studies show superiority to other methods. Most contemporary studies suggest that displaced (Garden III or IV) FNF in active community ambulators are indicated for THA. Existing osteoarthritis compromising the native acetabulum is also a justification for selecting THA over HA. The main factor in the decision to proceed with THA is the pre-injury functional level of the patient, though no clear consensus has been reached as to precise definitions of active or thresholds for chronologic age.[53,56,74] The National Institute for Health and Care Excellence (NICE) guideline uses 60 years of age.[75] Recent meta-analysis recommended patients with greater than four years of life expectancy or less than 80 years old be treated with THA due to equivalent dislocation rates with HA after four years.[76] The authors prefer the inclusion criteria recommended by NICE: age greater than 60, displaced FNF, independently mobile or case use pre-injury, medical fitness defined by American Society of Anesthesiologists (ASA) grade 2 or less, and cognitive fitness defined as an Abbreviated Mental Test Score of 8 or more.[75,77]

An advantage of HA is the preservation of native hip biomechanics compared to both THA and internal fixation with CSFN, when femoral neck shortening is considered.[53] The surgery is more invasive than cannulated screws and therefore results in greater blood loss. HA could be viewed as an intermediate between ORIF and THA in terms of operative time, blood loss, and overall surgical trauma. Primary THA theoretically minimizes reoperation risk due to internal fixation failure or hemiarthroplasty-related acetabular erosion. Some studies also claim superior function of THA in active patients. The traditional disadvantage of THA is higher rates of dislocation in comparison to HA.

Techniques for hemiarthroplasty differ in approach, components, and cementing. One meta-analysis comparing surgical approaches found the anterior and lateral approaches to be equivalent, and both were superior to the posterior approach in terms of dislocation risk and reoperation rates.[78] A second meta-analysis comparing the direct anterior to other approaches also found significantly lower dislocation rates and possible early functional mobility advantages with the direct anterior approach.[79] However, the 2021 AAOS CPG for geriatric hip fractures cites moderate strength of evidence for non-superiority of any approach, as newer high-quality studies have failed to support the historic claim of increased dislocation risk with the posterior approach.[80] In contrast, the 2011 NICE guidelines recommend an anterolateral rather than posterior approach for hemiarthroplasty.[75]

Meta-analysis comparing unipolar hemiarthroplasty components to bipolar components demonstrated equivalence in functional outcomes, leading to recommendations favoring unipolar due to decreased cost.[81] However, a more recent meta-analysis found bipolar hemiarthroplasty components were associated with better range of motion, lessened acetabular erosion, and lower reoperation rates than unipolar components.[82] Retrospective analysis of bipolar HA found a 10.3% rate of intraoperative periprosthetic fracture, with cementless stem and Dorr C femur (thin diaphyseal cortex) as the only significant independent risk factors. Most fractures occurred during trialing and reduction (53.6%) and the most common location was the greater trochanter (39.3%).[83]

Retrospective registry data found cementless HA had significantly higher revision rates at 18 months and 4 years, and 30-day lower respiratory tract infection rates.[84] A similar study of displaced FNF in patients at least 75 years old found a reoperation rate of 5% at 12-19 year follow-up for cemented HA, which was statistically superior to uncemented HA and internal fixation.[85] A prospective randomized controlled trial comparing cemented to cementless HA for displaced FNF found no functional outcome differences at one year.[86] A similar randomized controlled trial including patients without severe cardiopulmonary compromise and at least 70 years old found similar pain scores between cemented and uncemented. However, cemented implants had significantly less subsidence, fewer intraoperative or postoperative fractures, and better functional scores at some postoperative time points.[87] The AAOS cites strong evidence supporting their CPG recommendation in favor of cementing femoral stems during arthroplasty, and the NICE guideline concurs.[75,80] Evidence has not shown differences in patient outcomes for staple or suture closure.[72]

The techniques relevant to optimizing outcomes for total hip arthroplasty include surgical approach and cementation of the femoral component. A retrospective study comparing the anterior and posterior approach for displaced FNF treated with THA with at least 12 months follow-up found the posterior approach yielded significantly more postoperative complications and dislocations with no difference in modified Harris Hip Scores.[88] A retrospective cohort study comparing the direct anterior approach for displaced FNF treated with THA and elective THA found fracture patients had increased blood loss, operative duration, length of stay, and mortality. Operative duration and blood loss were greater for less-experienced surgeons, but surgery-related complications did not differ based on surgeon experience or between cohorts.[89] Recent meta-analysis comparing cemented to cementless THA for displaced FNF found fewer periprosthetic fractures with cemented femoral stems, similar readmission rates up to 180 days, and a higher incidence of medical complications, though the cemented group had significantly higher Charlson comorbidity indices.[90] For patients requiring conversion of a cemented HA to THA, a cement-in-cement technique mitigates operative difficulty with results comparable to revision THA, though overall complication rates are high.[91]

Fifteen-year follow-up in a randomized controlled study comparing two cannulated screws to cemented THA for displaced FNF (including 38% of cognitively impaired patients) found cognitively intact patients experienced failure rates of 55% (screws) and 5% (THA), and cognitively impaired patients experienced 16% failure in both cohorts.[44] However, as the bulk of the literature recommends arthroplasty over internal fixation for displaced FNF, comparisons of outcomes for total hip arthroplasty relative to hemiarthroplasty require more attention.

Many studies have been published illustrating a growing role for THA in geriatric displaced FNF, instead of HA. Seven to ten years of follow-up of patients in a randomized controlled trial showed a mortality rate following THA of 32.5% and 51.2% following HA despite no significant difference in age between groups, with a trend toward superior function after THA.[92] A retrospective study showed that 30-day-mortality after arthroplasty following acute fracture was 2.4%, nearly ten times higher than elective hip arthroplasty. No significant differences in 30-day-mortality were found for HA compared to THA.[93] A large retrospective database review of THA compared to HA for FNF found complication rates following THA have improved relative to HA. In the most recent time period transfusion rates become equivalent, major and minor complication rates favored THA, and operative time steadily improved while still favoring HA.[94]

Meta-analysis of displaced FNF treated with THA or HA found more dislocations for THA (RR 1.99), lower rates of reoperation for any cause (RR 0.53), higher Harris Hip Scores, but no difference in mortality or infection.[95] Another meta-analysis comparing THA and HA for displaced intracapsular fractures which integrated five RCTs and United Kingdom registry data found the RCTs reported no significant difference in 12-month dislocation, reoperation, or mortality rates while the registry reported significant differences with a THA dislocation sub-distribution hazard ratio (SHR) of 1.73, THA revision SHR of 0.66, and THA mortality SHR of 0.45.[77] A third recent meta-analysis comparing THA to HA for displaced FNF found that THA was superior to HA for Harris hip score, quality of life, and risk of reoperation (RR 1.54 for HA), and that increased dislocation risk became equivalent after 4 years.[76] Recent retrospective registry analysis of THA for FNF, including 41% cemented femoral components and 71% anterolateral approaches, resulted in a 5-year cumulative revision incidence of 8%, periprosthetic fracture incidence of 7%, and dislocation incidence of 1.4%, leading the authors to conclude that contemporary practices have improved rates of instability relative to previous studies.[96]

One justification for primary THA is the possibility of subsequent conversion of HA to THA. A retrospective cohort study comparing primary THA, revision THA, and HA conversion to THA found conversion to THA and revision THA had similar operative times and blood loss which were significantly higher than primary THA. But perioperative complication rates of conversion to THA were more similar to primary THA.[97] A Norwegian registry-based retrospective study comparing conversion from HA to THA with and without femoral stem retention found an increased risk of failure with retention of the original stem for both the entire construct (RR=4.6) and the acetabular cup (RR=4.8).[98] A large Medicare database cohort study comparing THA and HA for FNF found that at 2 years, fewer than 2% of HA patients were converted to THA, and reoperation rates were significantly lower for HA.[99] Another retrospective study investigating the conversion of HA to THA found 92% survivorship of HA at 10 years, with frequent major perioperative complications with conversion (45%), concluding revision outcomes mandate careful patient selection during the index procedure.[100]

Comparing outcomes of THA for displaced FNF to THA performed electively for osteoarthritis provides perspective, while surgeons must acknowledge inherent differences in patient selection. The previously discussed retrospective study comparing THA for FNF and elective THA using a direct anterior approach reported 1-year mortality rates of 6.6% (FNF) and 0% (elective), 5-year patient survival rates of 86% (FNF) and 93% (elective), and

80-month patient survival rates of 47% (FNF) and 53% (elective). THA for FNF had a 1-year mortality HR of 2.7 compared to elective THA, positively correlated with age, ASA classification, and time to surgery.[89] A prospective cohort study comparing cementless THA for FNF and elective THA with 10 years of follow-up found no significant differences in medical or surgical complications, mortality rates at two or ten years, or functional outcomes with the exception that more FNF patients required walking aids.[101] Although Parvizi et al. found tenfold 30-day mortality rates for THA for FNF compared to elective THA, a retrospective review reported THA for FNF patients had more pre-operative comorbidity and lower admission functional scores, required longer rehabilitation, but had superior improvement in PROM.[102]

Overall, the decision to proceed with hemiarthroplasty or total hip arthroplasty should be based on a holistic assessment of the patient. Patients unlikely to benefit from the theoretical functional advantages of THA and at risk of complications due to the increased operative trauma may be better suited for hemiarthroplasty. A recent randomized controlled trial comparing THA to HA for displaced femoral neck fractures found no difference in secondary procedures, and functional and quality of life advantages for THA did not meet clinically minimum difference thresholds.[103] However, although primary THA for FNF is more expensive than HA or ORIF, conversion surgeries are more expensive than primary THA. Patients likely to require THA in the future may benefit from eliminating an intermediate procedure.[42]

Operative Interventions – Intertrochanteric fractures

Treatment of intertrochanteric hip fractures is typically operative fixation due to the morbidity and mortality associated with immobility. The type of fixation depends on several aspects of the patient’s health, activity level, and fracture stability. Most of these fractures are treated operatively with either a SHS or cephalomedullary nail (CMN), although arthroplasty is also a rare option.

Operative fixation with a SHS is used to treat intertrochanteric fractures with a stable pattern and intact lateral wall. An advantage of this type of fixation is it allows for dynamic compression between fracture fragments. This method is also lower cost than intramedullary devices.[104] The NICE guideline favors extramedullary implants over intramedullary devices for trochanteric fractures above and including the lesser trochanter.[75] The major disadvantage, aside from the requirement for fracture stability, is the open surgical technique which can cause increased blood loss. Failure of this implant occurs if it is used with an unstable fracture pattern or screw malposition, where an ideal placement should have a screw tip-to-apex distance of less than 25 millimeters.[62] However, there are similar outcomes with SHS and intramedullary fixation when used for an appropriate fracture pattern.[105]

CMN is used to treat most types of intertrochanteric hip fractures. Indications include unstable fractures, involvement of the lateral wall, posteromedial comminution, displacement of the lesser trochanter, reverse obliquity fracture line, and subtrochanteric extension.[106] Intramedullary fixation is advantageous for the minimally invasive approach to minimize blood loss.

Arthroplasty as a treatment for intertrochanteric hip fractures is typically reserved for patients with a history of severe degenerative arthritis, salvage procedures for failed internal fixation, or severely comminuted fractures. Arthroplasty is also an option for patients with poor bone quality that will not hold internal fixation.[107]

There remains a 20-30% 1-year mortality rate following hip fracture, regardless of treatment choice.[108] Operative complications include infection, nonunion, and anemia secondary to blood loss. Implant failure for both SHS and CMN is typically a result of screw cutout which is caused by screw placement with a tip to apex distance greater than 25 millimeters.[108] Anterior perforation of the cortex of the distal femur is another possible complication specific to long intramedullary nails.[109]

Operative Interventions – Subtrochanteric fractures

Intramedullary fixation is the treatment of choice for subtrochanteric femur fractures. IMN is advantageous given the reduced operative time, decreased blood loss, and expedited time to weight bearing in comparison to fixed-angle plating.[110] Operative technique varies, beginning with patient positioning. Positioning the patient in the lateral position allows an easier reduction in the sagittal plane and access to a piriformis start point. The supine position allows aided reduction with the use of a traction table and provides more accurate rotational control.[111-113] The start point for nail insertion is another variable technical aspect. Piriformis fossa and trochanteric entry nails are available, although there is no reported difference in outcomes between the two.[114] This type of fixation provides relative stability and allows for secondary bone healing; however, it is important to preserve the blood supply to the proximal femur. Percutaneous reduction techniques are often used to aid in obtaining satisfactory reduction, though reduction aids placed at the fracture site have the potential to disrupt fracture biology.[115,116]

Fixed-angle plating is less commonly used, though indicated for subtrochanteric femur fractures with extension into the piriformis fossa or greater trochanteric region, as this may interfere with an adequate intramedullary nail start point.[117] These fixed-angle constructs require a non-comminuted medial cortex to convert tensile forces over the lateral cortex into compressive forces on the medial cortex.[118] Fixed angle plating utilizes an open reduction via a direct lateral approach, leading to increased blood loss and patients are typically non-weight-bearing post-operatively.

Fixation of subtrochanteric femur fractures is not without complications. Mortality rates have been shown to be as high as 27% more than one year after the fixation of subtrochanteric femur fracture.[119] The most common complication after fixation is malunion, specifically varus and procurvatum alignment.[120] Like other surgical procedures, possible complications include blood loss, malunion, nonunion, infection, and hardware failure. Specific to fixed-angle plating, loss of independence is an important but often overlooked part of the recovery process, given the non-weight-bearing restriction compared to immediate weight bearing with cephalomedullary nailing. Along with the much higher rates of failure, fixed angle plating has also been shown to have increased operative time, decreased union rates, and increased infection rates.[121]

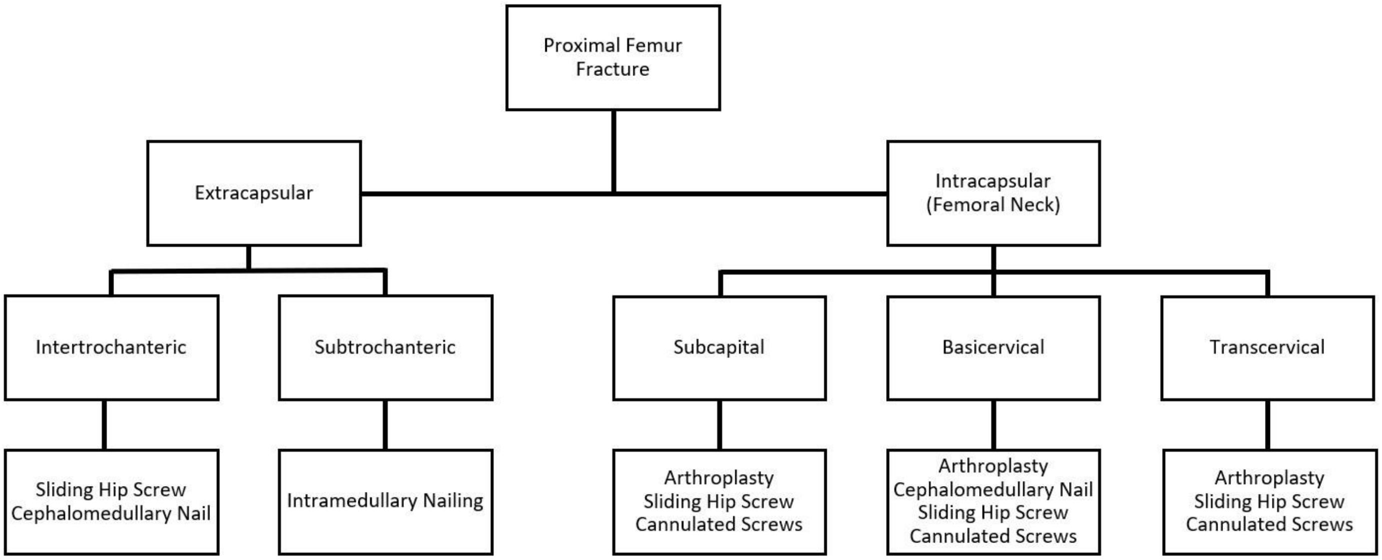
DISCUSSION

Recognition of the high mortality and morbidity associated with geriatric hip fractures has become more relevant among orthopedic surgeons and co-managing medical specialties alike as controversy regarding ideal management strategy continues to grow. The purpose of the current manuscript is to provide an operative counterpart to the previous work published by Perry et al. that comprehensively reviewed the medical management of geriatric hip fractures.[116] The key concepts reviewed in this manuscript are based upon the operative management of geriatric femoral neck, intertrochanteric, and subtrochanteric hip fractures.

Geriatric femoral neck fractures are almost universally treated surgically. However, there does exist a role of non-operative management in a minority of patients as highlighted within the results section. Surgical management consists of either internal fixation or arthroplasty (Figure 1). The most common constructs used for internal fixation are cannulated screw fixation (CSFN) and sliding hip screws (SHS). In the geriatric populous, internal fixation is generally reserved for non-displaced fracture patterns given the superiority of outcomes demonstrated with arthroplasty for displaced fractures. The literature has largely shown equivocal outcomes between CSFN and SHS, with subtle differences most notably identified by the FAITH trial.[61] For patients who do not have a fracture pattern or patient-related factors that may preferentially guide treatment with either a SHS or CSFN, then socioeconomic factors should be taken into consideration to guide implant selection. Widhalm et al. provided a comparative study in 2019 evaluating the use of SHS and CSFN for nondisplaced intracapsular neck fractures. They found the choice of the implant showed no significant impact on rates of revision surgery and complications.

However, they did find that in terms of socioeconomic factors, fixation with two cannulated screws was more favorable, making it the more cost-effective, and a more time and resource efficient method of fixation.[117] These findings can be considered in contrast to those reported by Zhang et al. in 2022 who investigated the efficacies of the Femoral Neck System (FNS) and CSFN. They found no

Figure 1. General treatment options for geriatric hip fractures based on anatomic location.



difference in hospitalization length and thus no difference in cost related to the hospital stay. This is with the caveat that implant costs are greater for the FNS than CNSF, as would be expected. However, with implant removal rates for the FNS group significantly less than the CSFN group (0% vs. 13.9%) over a 6-month follow-up period, the overall cost may be less with the use of the FNS, at least in the short term.[118] More studies are needed to further evaluate the overall cost implication of internal fixation methods utilized for femoral neck fractures.

The mainstay of management of displaced geriatric femoral neck fractures is arthroplasty. There remains controversy as to whether these injuries should be managed with hemiarthroplasty or total hip arthroplasty, as summarized above. Although primary THA for FNF is more expensive than HA or ORIF, conversion surgeries are more expensive than primary THA, so patients likely to require THA in the future may benefit from eliminating an intermediate procedure.[38] Thus, appropriate patient selection remains pivotal when considering a THA over HA, not only from a patient-outcome perspective but also when considering cost-effectiveness. This was demonstrated by Slover et al., who in 2009 demonstrated that THA was associated with an average cost of $3,000 ($4,127 inflation-adjusted) more than HA, and the average quality-adjusted life year gain was 1.53. This equated to an incremental cost-effectiveness ratio associated with the THA to be $1960 ($2,696 inflation-adjusted) per quality-adjusted life-year. While this was based on a hypothetical patient group (70 years old and otherwise healthy), others have demonstrated similar findings.[119] Ravi et al. in 2019 published a population-based retrospective cohort study on adults (≥60 years of age) undergoing either HA or THA for FNF to compare complication rates and healthcare costs. Aside from reporting a significantly increased risk for dislocation with THA v. HA (1.7% v. 1.0%) and a decreased risk for revision (0.2% v. 1.8%), they found an overall significant increase in the annual health-care expenditure cost in the year following the surgical procedure, which was approximately $2,700 Canadian dollars ($2,036 USD) lower in patients who underwent a THA.[120]

The most common subtype of geriatric hip fractures are intertrochanteric hip fractures. Fractures are typically classified based on the stability of the fracture pattern. The use of a CMN for unstable intertrochanteric hip fractures has been accepted as the gold standard, given the risk of failure with the use of a SHS in unstable fracture patterns. However, controversy continues regarding the use of a SHS versus IMN for stable fracture patterns, especially when considering cost. Brock et al. in 2019 evaluated the cost of care between patients with stable intertrochanteric hip fractures treated with a CMN v. SHS. They reported no statistically significant differences between CMN patients and SHS patients with regard to direct cost (total direct costs for both groups were over $20,000 for the hospitalization), contribution margin, or profit.[121] Similarly, DeAngelis et al. performed a retrospective cohort study of patients with stable IT hip fractures evaluating the cost of care between patients treated with CMN vs. SHS. They reported SHS and CMN patients had no significant differences in length of stay, direct costs ($22,324 +/- $10,603 vs $19,881 +/- $5,894), or health system profit (-$1,313 +/- $8,559 vs -$4,373 +/- $8,394). They concluded that differences in implant cost were insignificant compared to the total cost of care.[122]

This literature review has several limitations. First, the studies that were selected are a mixture of RCTs, case series, cohort studies, retrospective and prospective studies, and reviews. This limits direct comparisons among reports. Second, while the focus of the studies selected was on operative management of geriatric hip fractures, what patient age quantifies as geriatric remains ill-defined. Most consider patients aged 65 and older as geriatric (based on eligibility for Medicare). Nonetheless, several of the studies included patients younger than 65 years. Third, there are differences in guidelines published by the various authoritative organizations within orthopedics. Only a minority of these guidelines were included and reflected upon in this review as they related to the pertinent literature.

CONCLUSION

Hip fractures are among the most common orthopaedic injuries in the geriatric population and come with significant morbidity and mortality. Hip fractures are generally sub-categorized into femoral neck, intertrochanteric and subtrochanteric fractures. The current study provides a thorough review of the operative management of these fracture patterns based on current evidence and guidelines published within the orthopedic community. Femoral neck fractures are generally treated with internal fixation or arthroplasty. Internal fixation is reserved for non- or minimally displaced fracture patterns, whereas arthroplasty is the mainstay of management for displaced fractures and should be considered in the setting of valgus impacted/non-displaced patterns as well. Stable intertrochanteric hip fractures can be treated with either a SHS or IMN, with minimal difference in total cost. IMN is the implant of choice for surgical management of subtrochanteric hip fractures considering significantly higher rates of complications and cost burden associated with fixed angle plating.

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Chief Complaint: {left/right/bilateral} hip pain

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:
Shortened, externally rotate lower extremity
No lacerations, abrasions, or ecchymoses***
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: (As indicated)

MRI: (As indicated)

Duplex Scanning: (As indicated)

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

Plan:
- Admit to ***.
- Plan for OR (date***) for operative fixation of {left/right} hip
- 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