TRAUMA

Implant options for the treatment of intertrochanteric fractures of the hip

RATIONALE, EVIDENCE, AND RECOMMENDATIONS

Aims
The aim of this paper is to review the evidence relating to the anatomy of the proximal femur, the geometry of the fracture and the characteristics of implants and methods of fixation of intertrochanteric fractures of the hip.

Materials and Methods
Relevant papers were identified from appropriate clinical databases and a narrative review was undertaken.

Results
Stable, unstable, and subtrochanteric intertrochanteric fractures vary widely in their anatomical and biomechanical characteristics, as do the implants used for their fixation. The optimal choice of implant addresses the stability of the fracture and affects the outcome.

Conclusion
The treatment of intertrochanteric fractures of the hip has evolved along with changes in the design of the implants used to fix them, but there remains conflicting evidence to guide the choice of implant. We advocate fixation of 31A1 fractures with a sliding hip screw and all others with an intramedullary device.

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Fractures of the hip are arguably the most important public health problem faced by orthopaedic surgeons. More than 250 000 low-energy fractures of the hip occur in the United States each year. The International Osteoporosis Foundation estimates that approximately 1.6 million such fractures occur per year worldwide, a figure which may rise to six million by 2050. Their treatment consumes a growing percentage of healthcare expenditure.

The goals of care are to restore function with the lowest possible rate of surgical and medical complications. Achieving stable reduction and fixation of the fracture, permitting immediate mobilisation, is key to these goals.

The last 25 years has seen the introduction and increasing acceptance and use of intramedullary devices in preference to the sliding hip screw (SHS) for the treatment of intertrochanteric fractures. Despite little good quality evidence to support their use, most clinicians use them for most fractures, and practice guidelines from the American Association of Orthopaedic Surgery (AAOS) support their use. In this paper we review the evidence and highlight the weaknesses or absence. We also present our practice with its rationale and recommendations.

The pertrochanteric region has many thickenings of trabecular bone in compressive and tensile groups. The most structurally significant of these are the primary compressive trabeculae along the posteromedial femoral neck and shaft. While several classification systems exist for these fractures, they are all based on the concept of stability. A stable fracture is a simple one that, once reduced and fixed, is compressed and minimally impacted by the nearly perpendicular weight-bearing force of single leg stance. Unstable fractures due either to comminution, ‘reverse oblique’ orientation, or both, are associated with collapse on axial loading. Both the postero-medial cortex and the lateral cortical buttress beneath the vastus ridge contribute to the stability of these fractures. The instability increases with the degree of comminution of the postero-medial cortex. Increased comminution implies less support for axial loading through cortical contact. The lateral cortex beneath the vastus ridge provides the final buttress to impaction of the fracture after fixation, further contributing to its stability and avoiding collapse. Incompetence of either of these cortical regions therefore renders a fracture unstable.
The quality of reduction, regardless of the pattern of the fracture, is one of the most important modifiable factors in the management of intertrochanteric fractures. The ability of the cortex to resist collapse in stable fractures depends on the restoration of cortical continuity. In unstable fractures, where the ability to restore this is limited by comminution or the orientation of the fracture, the bone-implant interface will be subject to increased stress. Implants used to fix unstable fractures must, therefore, be capable of bearing more load, in order to avoid loss of reduction through collapse. A valgus reduction is one way of increasing interfragmentary compression and of reducing bone-implant stresses, as well as minimising collapse and leg length discrepancy.

Studies of implant loading confirm that the load borne by an implant is increased with varus mal-reduction and with decreasing stability of the fracture, and that in both cases an intramedullary device can bear greater load than an extramedullary device. 11,12

The Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association classification system for pertrochanteric fractures. Copyright the AO Foundation, Switzerland. (Source: AO Surgery Reference.)

![Fig. 1](image)

Involvement of the lateral cortex is only a specific criterion of fractures in the A3 category and is an important factor in loss of reduction when using an extramedullary SHS system. 16 Intra-operative fracture of the lateral cortical buttress is significantly more common in A2.2 and A2.3 fractures than in A2.1 fractures, 8 emphasising the importance of recognising the A2 sub-type when choosing the implant by which it will be managed.

A surgeon’s familiarity with a specific implant may have a measurable effect on the operating time, the use of fluoroscopy, intra-operative blood loss and the need for transfusion, but a systematic review of the evidence reported significant heterogeneity in published data and an implant-associated effect has not therefore been shown. 17

There is an increasing cost associated with SHSs, short nails and long nails, respectively. 18,19 Intramedullary implants are between 20% and 40% more expensive than SHSs and so, if each is appropriate for fracture fixation, the less expensive device should be used. A recent American College of Surgeons National Surgical Quality Improvement Program database study reported a shorter mean post-operative length of stay following treatment with an intramedullary implant. 20 This study did not stratify the patients by the type of fracture and hence the effect was seen across all groups, implying that the greater cost of the implant may be offset against the ongoing cost of care by using the intramedullary device in all patients.

Cost-effectiveness analysis that models length of stay, rehabilitation or re-operation is dependent on the data used for the model, in particular those used to inform the rate of failure. One such study suggested that extramedullary
implants are more cost-effective for A2 fractures, but assumed an equivalent rate of failure between SHSs and nails. Such an assumption ignores differences in outcomes, especially when considering the A2 group as a homogenous one.

Late costs are more difficult to measure and tend to relate to failure, requiring prolonged rehabilitation or reoperation. First-generation intramedullary implants had a significantly higher incidence of periprosthetic fracture, thereby compounding their already increased cost. A 4.5-fold increased risk of periprosthetic fracture in 1997 decreased to 1.87 in 2005 and is no longer evident in the most recent data.

Despite a large number of randomised controlled trials (RCTs), meta-analyses have not shown differences in functional outcomes between intra- and extra-medullary devices. These studies have often used inappropriate outcome measures and reported the outcome of diverse cohorts of patients, pooled without reference to pre-operative functional status. Some authors have, however, shown differences in the rates of recovery of function. In a RCT of intramedullary versus extramedullary fixation in 210 patients with A1 or A2 fractures, Utrilla et al reported no difference in outcome in stable fractures, but better mobility at one year following intramedullary fixation of unstable fractures. Improved early functional recovery following intramedullary fixation has also been shown in several studies which also recorded sliding of SHSs, indicating shortening of the femoral neck, leg length discrepancy, and/or medialisation of the shaft. Pajarinen et al reported improved mobility and less shortening of the femoral neck after intramedullary fixation in agreement with the findings of Hardy et al of improved early mobility, less sliding and less leg length discrepancy. The early functional recovery is better in those in whom the SHS slides less, suggesting that excessive alteration of the biomechanics of the hip can impair the recovery of mobility. A recent RCT by Reindl et al found less shortening of the femoral neck in the intramedullary group, but this did not significantly alter the timed up and go scores. It is likely that the ability of a patient to tolerate malunion is related to pre-injury function, but there is currently no evidence to support this as studies tend to pool all patients. Information about functional outcomes such as return to social integration, driving and participation in recreational activities is urgently needed.

**Implant details**

**The length of the nail.** Early intramedullary nails used for fractures of the hip were short and associated with a risk of fracture at the tip of the nail, with an incidence of 8% to 11% historically. Long nails can prevent this complication but risk anterior cortical impingement or intra-operative iatrogenic fracture with incidences of 1.5% and < 1% recorded. For this reason, the surgeon must be conscious of the design of the nail including its radius of curvature and the anterior bow of the femur. A stress riser can, in this scenario, lead to a fracture which is even more challenging to manage, especially with a nail in situ.

No significant difference in the rates of periprosthetic fracture between short and long nails have been recorded at one, two or five years post-operatively. Longer nails can cost up to 45% more than short nails. Lindvall et al reported that, based on a rate of periprosthetic fracture of 12% and an increased cost of $439 of long nails over short, long nails were cheaper than short ones when the cost of managing complications was taken into account. A more recent study reported equivalence between short and long nails, except for hospital costs (which can include facility fees, cost of medications given, administration of the medications, lab costs, cost of surgery and anesthesia).

Leaving aside the biomechanically dissimilar subtrochanteric fractures, there is little evidence relating to short versus long nails in terms of functional outcome and until these data are known, meaningful assessment of cost benefit is difficult.

**Distal locking.** The effect of distal locking on the incidence of periprosthetic fracture is not fully understood. Lindvall et al reported that distal locking may be protective against periprosthetic fracture in both short and long nails. In their cohort of 609 patients, 47% of nails were distally locked but 15 of 16 periprosthetic fractures occurred in the 53% of patients with unlocked nails at 21.5 months (standard deviation (SD) 18.6) follow-up in the short nail group and 14.8 months (SD 13.8) follow-up for long nails. They also noted that patients with unlocked long nails experienced periprosthetic fracture around the shaft, while those with locked long nails had fractures at the tip of the nail. In short unlocked nails, fractures occurred at the tip of the nail, in keeping with early findings in studies of intramedullary fixation. This is important as, in relative terms, it is easier to treat a diaphyseal fracture by closed reduction with the introduction of a distal locking screw than it is to perform open reduction and internal fixation of a peri-articular fracture around a locked nail.

Current evidence supports distal locking in axially or rotationally unstable fractures, including those with subtrochanteric extension or comminution, or in osteoporotic femora in which it is hard to achieve an isthmic fit.

**Femoral head fixation: blade vs screw, one vs two**

Some intramedullary implants use a helical blade for fixation of the femoral head instead of a cancellous screw. Biomechanical studies in artificial, cadaveric and living bone have shown that a blade resists rotational and translational displacement better but this has not translated into evidence of a difference in rates of cut-out, complications, or post-operative function. Consistently, loss of fixation is more related to the quality of reduction of the fracture and a high tip-apex distance (TAD) rather than the choice of implant.
The use of blades may be associated with the phenomenon of ‘cut-through’ with medial perforation of the articular surface of the femoral head without loss of reduction of the fracture. This is in contrast to ‘cut-out’, superior and anterior migration of the screw as the fracture displaces and the femoral head moves into varus and retroversion. In order to avoid ‘cut-through’, it has been suggested that the full length of the trajectory of the blade is not pre-drilled and that the tip of the blade should be a minimum of 10 mm from the joint surface.40,41

There are variants with both one (uniaxial) and two (biaxial) screws in the femoral head. Greater load to failure has been reported with biaxial screws in a biomechanical study,42 but this advantage has not been reported clinically and complications of axial and reverse axial migration (the ‘Z’ and ‘reverse Z’ effects) have been described.43 A prospective RCT by Kouvidis et al43 showed no difference in outcome (activities of daily living or mobility) between an SHS group (60 patients) and a biaxial intramedullary nail group (62 patients) at 1 year follow-up. The single systematic review of such devices suggests that biaxial fixation leads to a lower risk of post-operative periprosthetic fracture than uniaxial fixation.44 This review examined only periprosthetic fracture however, without recording any other outcome or complication, including those specific to biaxial fixation.

Proximal femoral locking plates offer a lower load to failure than cephalomedullary devices and have higher rates of mechanical failure and re-operation.45

Much of the evidence supporting the use of newer designs of implant is biomechanical and must be interpreted carefully to understand the clinical relevance. The native hip may be loaded in different directions and different ways and the evidence should be evaluated with caution.

**Tip-apex distance and other targets**

Both ‘cut-out’ and ‘cut-through’ emphasise the importance of the correct placement of the screw in the femoral head, namely central and deep.46 The TAD is an accepted and reproducible means of evaluating this.46 A recent variation, the ‘calc-t-TAD’, aims to target a slightly inferior placement of the screw when using cephalomedullary devices. This reflects existing practice in both SHSs and intramedullary devices, based on there being stronger bone in the calcar and inferior femoral head.47,48 It has not, however, been confirmed that this offers better fixation than when placing the screw in the centre of the femoral head.49,50 In the multivariate analysis of Kashigara et al,49 only the calcar-TAD was found to be a statistically significant predictor of failure and although the authors concluded that inferior placement conferred benefit, the reduction of the fracture was classified as poor in almost half of the 77 patients at a mean follow-up of 408 days (81 days to 4.9 years). This, therefore, confounded the suggestion that the position of the screw was predictive of the outcome, as varus mal-reduction was also significantly associated with failure.

**Discussion**

**Stable intertrochanteric fractures (A1 to A2.1).** There is currently little evidence of the superiority of one device over another in the management of these fractures.5,25,28,51

The quality of reduction remains paramount, with stable fractures having direct cortical contact following accurate reduction. At our institution there is a preference for SHS fixation after careful reduction.

**Subtrochanteric and reverse oblique fractures (A3).** There is strong evidence to support the use of intramedullary fixation in subtrochanteric and reverse oblique fractures. The biomechanics of these fractures are such that fixation with a SHS is inappropriate, as the line of collapse is not perpendicular to the fracture line and the lateral cortical buttress cannot resist collapse. The use of a trochanteric sliding plate (TSP) offers increased resistance to collapse, but the fixation is less reliable than when using an intramedullary device, which offers better functional outcomes and rates of union.27,52,53-57 Worse outcomes are also associated with the use of proximal femoral locking plates.58 Intramedullary nails resist collapse both by their intramedullary position and by an enlarged proximal end, offering an internal buttress. The minimally invasive nature of the surgery also preserves the vastus soft tissue envelope, maintaining stability and vascularity.

**Unstable intertrochanteric fractures (A2.2 to A2.3).** Current guidelines recommend the use of an intramedullary device for the treatment of these fractures.5

As in subtrochanteric and reverse oblique fractures, the use of a TSP may prevent excessive collapse in unstable fractures lacking a posteromedial or lateral cortical buttress in which an SHS is used.

A randomised prospective study comparing fixation using a SHS (343 patients) or intramedullary nail (341 patients) for all intertrochanteric and subtrochanteric fractures showed no long-term differences in outcome at three and 12 month follow-up, with improved early pain on mobilisation scores in the intramedullary group.59 Importantly, a TSP was used in A3 fractures and optional in osteoporotic A1 and A2 fractures when the lateral cortical buttress was questionable. The equivalence of outcome between these constructs emphasises that maintenance of a good reduction and prevention of collapse offers optimum function. Medialisation of the femoral shaft was seen more frequently in the SHS/TSP group and was associated with increased post-operative pain. Overall, an intramedullary device appears from the evidence to offer more benefit than an SHS with TSP.

**Basicservical fracture.** True basicervical fractures are uncommon and, although extracapsular, have similar rotational instability to those occurring more medially in the femoral neck. A simple two-part basicervical fracture requires reduction with direct cortical contact, and stable, compressed fixation. A de-rotation screw may offer increased protection against rotational loss of reduction. A comminuted fracture with basicervical extension should be treated.
as a comminuted, unstable intertrochanteric fracture with an intramedullary device.

The role of arthroplasty. Certain unstable intertrochanteric fractures of the hip can be treated by arthroplasty. Indications include existing arthritis, osteonecrosis of the femoral head, poor quality of bone or complications following internal fixation.60 There is limited evidence for the role of arthroplasty in treating unstable intertrochanteric fractures, with benefits including early mobilisation.60 The surgery is technically challenging and should be undertaken by an experienced arthroplasty surgeon.

In conclusion, decision-making in the management of intertrochanteric fractures requires a thorough understanding of the stability of the fracture and the implants which are available. More evidence on functional outcomes is needed, especially in higher-functioning patients. It remains of critical importance to pay careful attention to the quality of the reduction and central and deep positioning of the screw or blade, regardless of implant.

Take home message:
There is conflicting evidence about the choice of implant in the treatment of intertrochanteric fractures of the hip, but assessing the stability of the fracture allows one to choose between fixation using a DHS or an intramedullary device.

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A. R. Socci: Primary researcher and writer.
N. E. Casemyr: Researched and wrote significant portion of introduction, editing and revising.
M. P. Leslie: Wrote a section on technical aspects of reduction which was not included, participated in the revision process.
M. R. Baumgaertner: Provided necessary oversight and guidance, focused the work on the most relevant references, concepts and controversies, heavily involved in editing and revision.

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References


