Intramedullary nailing of femoral shaft fractures in adults

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Abstract

Diaphyseal femoral fractures are common and can present as isolated injuries or as part of a polytrauma situation. Management of these fractures requires an understanding of the timing of definitive surgery in systemically unwell patients, as well as the physiologic effects of reaming and instrumentation of the femoral canal. An appreciation of biomechanics of femoral nails, along with other implants, and the nuances of their application is essential in achieving a satisfactory outcome.

Keywords adult; diaphysis; femoral fractures; femur

Introduction

This review will focus entirely on intramedullary nailing for diaphyseal femoral fractures in adults. Other methods of fixation, paediatric fractures and fractures of the proximal and distal femur are beyond the scope of this review. In addition, the physiological effects of these injuries and their treatment will not be covered. High-energy and open fracture patterns have been covered in a previous article[1] and a discussion on the management of vascular injuries associated with fractures requires an entirely separate review.

Epidemiology

The average annual incidence of femoral fractures has been quoted to range from 0.1 to 3% (up to 37 per 100 000 patient years), with peak incidence in young adult males.[2–5] Association with major trauma and high-energy mechanisms are seen in this age group. A second peak in incidence, with low energy mechanisms is seen in the elderly population.

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Anatomy/blood supply

The femoral shaft is curved in the sagittal plane with an anterior bow. The cortex is thickened posteriorly for two reasons: it is the compression side of the bone in the sagittal plane, and also carries the linea aspera. Distally the cortex thins and expands into the metaphysis. The central anatomical axis of the neck is offset anteriorly to the central anatomical axis of the shaft in the sagittal plane. The neck-shaft angle is of approximately 130° (124−136°) in the coronal plane.

The blood supply to the femoral head arises from the anastomotic ring around the base of the neck, which superiorly traverses the piriformis fossa − thus putting it at risk when using this as an entry point in nailing. Blood to the diaphysis is supplied via both the higher pressure endosteal system (from the nutrient vessels) and the lower pressure periosteal system (from the areas of muscle attachment), accounting for the inner 2/3 and outer 1/3 of the cortex's blood supply respectively.

Reaming initially reduces the endosteal blood supply, although any instrumentation of the femoral canal (such as with an unreamed nail) also has a significant effect (see below). With increasing age, the morphology of the femoral diaphysis changes, with endosteal resorption and periosteal apposition of bone. This leads to the characteristically wider femoral shaft but thinner cortex, often compounded by an increase in the anterior bow.

Classification

The two most commonly used classifications for diaphyseal femoral fractures are the AO-OTA system (Figure 1) and that described by Winquist (Figure 2). Both systems are useful in predicting the axial and rotational instability of the fracture and therefore help with management planning. Neither is necessarily predictive of outcome or time to union.

Winquist described the degree of comminution in a fracture and thus the degree of cortical contact or continuity.[7] The classification has been modified to include segmental bone loss as well as non-comminuted fractures (Table 1).

Assessment and initial management

In the polytrauma and major trauma situation, patients are typically assessed and managed according to standardized protocols such as the Advanced Trauma and Life Support (ATLS) system. Femoral fractures can be a major source of blood loss and should be temporarily splinted as a means of haemorrhage control.

Splintage of the femoral fracture provides the best analgesia and can allow for gross correction of rotational malalignment. This can initially be performed in the form of fixed-point traction such as the Thomas or Kendrick traction splints. These splints should be removed early to avoid the risk of pressure necrosis and pudendal nerve injury. Balanced traction (skin, skeletal) can be used in patients who are waiting for surgery but who are physiologically well. Adequate oral and intravascular analgesia and regional femoral nerve block with local anaesthetic should be considered.

Definitive treatment: intramedullary nailing

Rarely are fractures of the femoral shaft in adults treated without operative intervention. Skin or skeletal traction as definitive

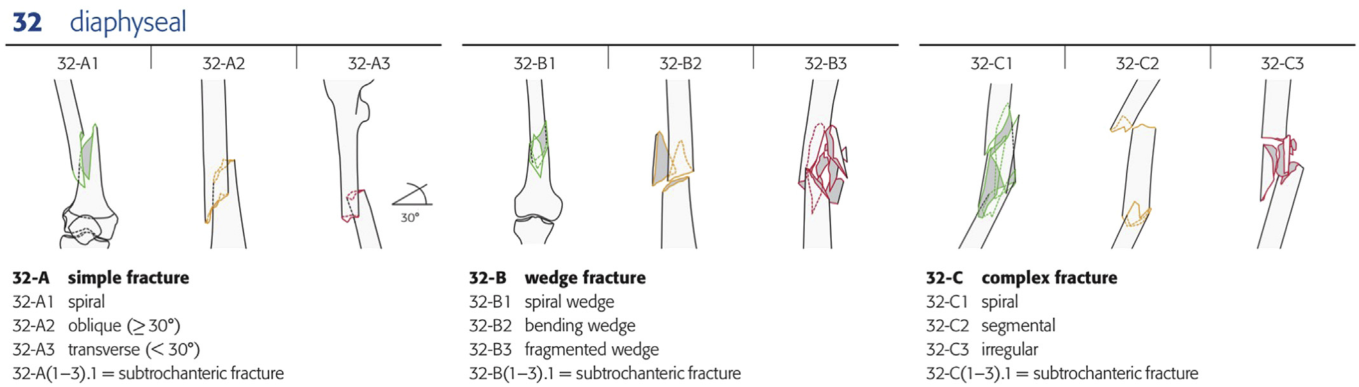

Figure 1 AO-OTA classification of femoral diaphyseal fractures.[6]

methods of fixation are now largely historical. Non-operative methods lead to high rates of malunion and shortening. The commonest surgical method of treating femoral shaft fractures is with the intramedullary nail. Modern nailing had its roots with Küntscher in 1939, but descriptions of intramedullary devices have been found from well before the 20th century.[9]

Nail design

Despite early scepticism of the methods of Küntscher, the concept and use of nailing was eventually embraced and nails have now evolved into highly engineered orthopaedic devices. Nails are typically made from either titanium or stainless steel. Even though titanium has an elastic modulus approximately half that of steel, a difference in material has little effect upon union or failure rates with modern generation nails. The stiffness of the implant is related to the fourth power of the radius of the nail, therefore the fatigue strength is significantly higher in nails of a larger diameter. Nails with an external diameter of 11–12 mm have a bending stiffness over 50% greater than smaller cannulated nails.[10]

Older generation nails were typically thin walled and may or may not have been slotted. Although these nails offered excellent interference fit within the femoral canal, they were weak in torsion, Modern generation nails are thick walled and no longer rely on the slotted geometry to facilitate insertion, but rather rely more on anatomic contouring. Typically nails now have a radius of curvature (150 cm) that is nearer that of the radius of curvature of the femur (approximately 120 cm) compared to older, straight nails. Most modern generation nails are cannulated to facilitate insertion – by keeping the cannulation small, the effect of its presence on the strength of the nail is minimised. Flutes may be present to facilitate rotation of the nail, and to reduce intramedullary pressure at the tip of the nail on insertion. All modern nails offer multiple locking options proximally and distally.

Patient set up

Femoral nailing can be performed freehand on a radiolucent flat top trauma table, or in traction on a fracture reduction table. Both can be used with the patient either supine or in a lateral position.

Faster operating times and less malreduction have been shown with freehand techniques, but there is no difference in functional outcome or other parameters.[11] Traditional fracture table techniques rely on the application of traction through the leg extension with foot piece, or via a traction pin in the distal femur. This allows application of traction, rotation and correction of varus/valgus and flexion/extension. The Posterior Reduction Device (PORD) (Orthofix: Lewisville, Texas; Verona,

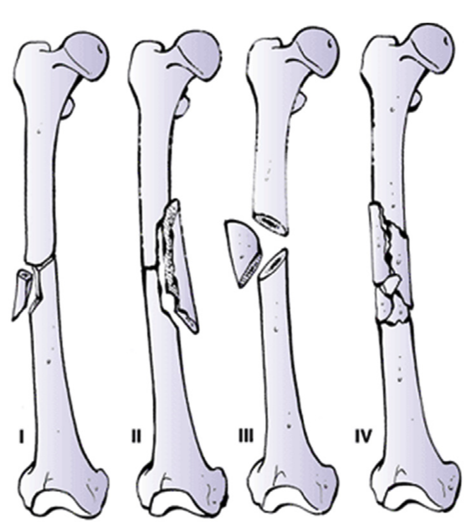

Figure 2 Winquist classification of femoral diaphyseal fractures.[8]

Modified Winquist classification of femoral diaphyseal fractures to include Types 0 and V

Type	Description
0	No comminution
I	Small butterfly fragment <25% of circumference
II	Larger butterfly fragment <50% of circumference
III	Very large butterfly fragment >50% of circumference. Only a small area of cortical contact remains
IV	No cortical contact. Segmental fracture
V	Segmental bone loss

Table 1

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