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Review Article

Complications of Femoral Intramedullary Nailing: What should the Surgeon Remember?

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Abstract

Treatment of femoral fractures using the technique of intramedullary nailing is one of the commonest procedures in routine orthopaedic practice. Despite the significant improvements complications still do happen. We collected and analyzed all the relevant and up-to-date evidence regarding complications associated with femoral intramedullary nailing and we present it in an abbreviated and concise manner. We believe that this serves an educational purpose for both young and senior surgeons who get involved in consenting and operating in patients suffering from such fractures. This collective reminder offers the acknowledgement of the risk which is the first step to avoid a complication and also summarizes advice.

Keywords: *Femoral; Intramedullary Nailing; Complications; Review*

Introduction

The treatment of femoral shaft fractures was revolutionised by Küntscher who was the first to introduce the intramedullary nailing concept [1]. The initial indications were limited to transverse diaphyseal femoral fractures but advantages such as early mobilisation, shorter hospitalisation and lower morbidity popularised the wider use of femoral nails [2,3]. Improvements in nail design and manufacturing as well as surgical technique, with the use of a fracture table and X-ray image intensifier, broadened further the use of femoral nails but it was the introduction of an interlocking capability in the mid-1970s that expanded the scope of indications to include comminuted and fractures of the proximal and distal thirds [4,5]. Proximal and distal locking of the intramedullary nail provides longitudinal and rotational stability. Over the last three decades closed intramedullary nailing has become the gold standard technique for the treatment of femoral shaft fractures [6].

However, its widespread use poses surgeons to variable complications in both intraoperative and postoperative course.

Thermal necrosis

Intramedullary reaming increases stability at fracture site allowing insertion of bigger and more rigid nails but disrupts cortical blood flow and can cause variable degrees of thermal necrosis [7]. Cortical reaming and nail insertion injure the medullary blood supply, and this results in avascularity of one-half to two thirds of the diaphyseal cortex [8,9]. The extent of intramedullary reaming correlates directly to the degree of cortical blood flow reduction [10]. However experimental studies showed that both reaming and unreaming share the same callus perfusion resulting in similar union rates [11]. An increase in extracortical callus perfusion may compensate for the disturbed endosteal perfusion associated with nail insertion and reaming. It is supported that destruction of endosteal circulation leads the blood flow to be centripetal so the bone revascularises from outside to inside with the reversal of flow of periosteal vessels [12]. In open fractures this periosteal compensatory mechanism is expected to be disrupted.

Apart from the vascular osseous changes the internal endosteal friction between the reamer and the bone elevates intramedullary temperature [13]. A study in 1987 showed that average intramedullary temperate rises up to 67°C in a standard femoral nailing [14]. Cellular enzyme denaturation occurs at the critical temperature of 56°C which is the point of thermal necrosis [15]. Of course this is also time dependent. Elevated temperature to 47°C for more than 1 minute results in bone necrosis and impaired bone formation [16]. Smaller and sharper reamer result in milder elevation of temperature [17].

Intramedullary reaming leads also to elevation of femoral canal pressure. This elevation was found to be relevant to the intramedullary contents by Küntscher in 1950 [18]. The biggest pressure values are noted in initial reaming when all intramedullary content is present and maximum pressure increase when reamer enters the distal fragment [19]. Pressure can be decreased using less compressive force, sharper reamer and increasing the reaming speed. Intramedullary pressure elevation above diastolic blood pressure leads to bone marrow embolisation via venous outflow [20]. Therefore, patients who undergo femoral nailing undergo transient vascular changes like pulmonary vascular resistance increase but mostly remain asymptomatic [21]. Intraoperative transesophageal echocardiography (TEE) proved that solid emboli occurred after at the level of 200 mmHg of intramedullary pressure [22]. However if patient is generally healthy with limited comorbidities and without chest trauma can usually tolerate this embolisation. RIA (Reamer-Irrigator-Aspirator) is a system that reduces the viscosity of medullary fat and facilitates the suction of the bone marrow content resulting in low intramedullary pressures and it may well be a solution when increased intramedullary pressure is a problem [23]. Furthermore, reamed femoral nailing is associated with greater impairment of immune reactivity and with an increased consumption of coagulation factors [24].

Nerve injury

Pudendal nerve palsy is another complication that may happen as a result of a femoral intramedullary nailing. It occurs as a compression neuropathy due to pressure between the perineum and the counter-traction post. The exact incidence of pudendal nerve palsy remains unclear due to under-reporting by patient and physician. The sensory terminal branches of the pudendal nerve appear more susceptible to injury than do the motor branches which control sexual function [25]. It seems that this complication is frequently overlooked or it is not often investigated in big series. In a prospective study of 106 patients, 10 of them have developed sensory loss which resolved in 6 weeks apart from a male where erectile function took 11 weeks to recover [26]. In a retrospective study 10 (15%) of the 63 patients were noted to have pudendal nerve palsies following surgery [27]. Of the ten patients, 7 had pure sensory loss and 3 males had erectile dysfunction. All ten patients regained full sensation and normal function at varying intervals, the longest period for return of sensation and erectile function being 5.8 months and two months respectively. Because the smaller diameter perineal post of the traction table concentrates the traction forces in a smaller contact area, the narrowest post has been blamed as a causative factor in pudendal nerve palsy after IM nailing. Published guidelines to avoid this complication advocate the application of adequate pre-operative skeletal traction to avoid shortening while awaiting for surgery, complete muscle relaxation, release of traction when the interlocking screws are inserted and the final diameter of perineal post should be from 6.8 to 9 cm [25]. Sciatic nerve injury is a rare complication and has been found to be more probable in retrograde rather than antegrade nailing [28]. In another study pudendal nerve injury was estimated to 7.2% and peroneal palsy to 1.2% all attributable to traction but recovered with time [29]. In retrograde femoral nailing in order to avoid the femoral neurovascular bundle or the sciatic nerve especially when acetabular fracture is present it has been advocated lateral to medial screw insertion rather than antero-posterior proximal locking screw insertion [30].

Vascular injury

Femoral nailing poses a risk to femoral artery, both the deep femoral (DFA) as well as the superficial femoral artery (SFA). Screw or drill penetration can cause aneurysm or catastrophic hemorrhage leading to acute compartment syndrome and death. A CT angiographic study showed that distal screws in short nails used to treat hip fractures are more prone to damage the DFA, whereas at that level SFA is away from the short nail. SFA lies posterior to long nail so overall the long nail is less likely to cause femoral arterial damage [31]. A recent study in 2017 revealed that the middle femoral zone is the most risky for developing a vascular injury especially in DFA and PFA (profunda femoral artery) [32]. Therefore authors recommend great attention when screws are inserted in midshaft region. In retrograde femoral nailing proximal locking usually takes place in antero-posterior free hand fashion and the zone proximal to lesser trochanter is considered as safe [33]. However, a case report of an injury to a branch of PFA shows that anatomical variations do exist [34]. Another three dimensional (3D) CTA study identified that in all zones around lesser trochanter arterial branches wider than 2 mm can be found. Therefore, authors advocate avoiding medial drilling placement, use of blunt dissection, use of a drill sleeve or alternatively drill in an oscillating mode [35]. Rare case of superior gluteal artery injury in nailing of an atypical subtrochanteric fracture has also been described [36].

Iatrogenic fracture

Perioperative fracture is one of the most usual complications during femoral nailing. Fracture of the greater trochanter can easily happen during establishment of entry point in antegrade nailing especially in osteoporotic bone. Femoral neck fracture has been frequently described as a known iatrogenic complication of femoral shaft nailing [37,38]. Two cases of iatrogenic femoral neck fracture in an aggressive attempt to remove a misplaced end cap have also been described [39]. Penetration of distal anterior femoral cortex is a well described and significant complication relating to the mismatch of radius of curvature between the nail and the femur [40]. Other contributing factors are an anteriorly placed trochanteric entry point or the fact that the femoral medullary canal lies slightly anterior within the distal femur and the anterior femoral cortex undergoes significant thinning with age. Although rare, anterior cortical perforation is a significant complication requiring altered weight bearing and sometimes revision surgery. Fractures distal or around the nail tip occur when the nail acts as a stress riser therefore a nail long enough to reach the broad supracondylar region or even the physical scar is strongly advocated [41]. Regarding retrograde femoral nailing medial femoral condylar fractures have also been described as a complication therefore the significance of a correct entry point should never be overlooked [42,43].

Malalignment

A disadvantage of IM nailing compared to plating is less ability for rotational and angular control. Malalignment is one of the biggest fears of orthopedic surgeon treating a long bone fracture. Clinical measurement of rotational malalignment is not considered reliable [44]. The most reliable method is use of CT examining both legs [45]. Torsional differences between the two legs of less than 10° are considered normal variations [46]. Between 10 and 14 degrees is debatable and more than 15o is considered a true rotational deformity. Jaarsma., *et al.* found an incidence of 25% of rotational malalignment in their series of 76 treated patients [47]. According to them, torsional deformities were irrespective of fracture level and internal was better tolerated than external rotation especially for demanding activities like sports. Comparing the shape of lesser trochanter in image intensifier with the unoperated one may be an adjunct to avoid rotational discrepancies [48]. Angular malalignment is another complication secondary to femoral nailing [49]. Ricci., *et al.* stated that a variable incidence of angular malalignment varying from 0 - 37% is stated in the literature and this is due to the inconsistent use of either 5 or 10 degrees as a threshold. They used 5° in any plane as cutoff for angular deformity. In their 374 cases 33 (9%) exhibited angular deformity. Proximal third fractures had the biggest incidence of malalignment (30%) with distal fractures accounting 10% and middle third 2%. Nail diameter and method of treatment (ante- vs. retrograde) were not a statistically significant independent predictor of greater angulation. However proximal femoral fractures were doing better with antegrade nailing and distal femoral with retrograde implants whereas middle thirds were doing the same with either methods.

Finally, comminuted fractures can be also complicated by longitudinal malalignment resulting in leg length discrepancy [51]. This, if clinically significant, can cause pelvic tilt, hip joint space narrowing and back pain. However, in the series of Herscovici., *et al.* only 6 (7%) of 83 patients with comminuted femoral fractures had leg length discrepancy more than 1.25 cm and from them only the 4 resolved to revision surgery.

Conclusion

The list of what can go wrong during a femoral intramedullary nailing is long and cannot be exhaustive. We presented here the most basic, significant and common complications arising from this technique along with limited advice. Our target was to offer up-to-date and essential analysis of risks recognizing that knowledge is for the surgeon the first step to avoid an untoward incidence.

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