Injury, Int. J. Care Injured 48S (2017) S18–S21

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Insertion-related pain with intramedullary nailing

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ARTICLE INFO

Keywords:
Intramedullary nail
Insertional pain
Etiology
Incidence

ABSTRACT

The use of intramedullary nails for the treatment of long bone fractures has become increasingly frequent over the last decade with gradually expanding indications and technological advances. Improved biomechanics relative to plates and less direct fracture exposure are some of the potential benefits of intramedullary nails. However, persistent insertion-related pain is common and may limit satisfactory long term outcomes. The etiologies of this phenomenon remain unclear. Proposed theories for which there is a growing body of supporting evidence include hardware prominence, suboptimal nail entry points leading to soft tissue irritation and structural compromise, local heterotrophic ossification, implant instability with persistent fracture micromotion, and poorly defined insertional strain. Many factors that lead to insertion-related pain are iatrogenic, and careful attention to detail and refined surgical techniques will optimize outcomes.

Introduction

Intramedullary nail fixation of long bone fractures has increased dramatically in recent years [1]. This shift is largely due to advances in implant technology and the recognition of mechanical advantages of intramedullary versus extramedullary fixation. Additional clinical benefits include increased opportunity for biologic-friendly reduction techniques with less direct fracture exposure and load sharing properties of nails leading to earlier weight-bearing and faster rehabilitation [2–13].

Despite the many advantages of intramedullary fixation, post-operative or insertional nail pain after fixation of femur, tibia, and humeral fractures remains a common and poorly understood problem. Obremskey et al. reported that 11% of 437 patients with tibial shaft fractures treated with infrapatellar intramedullary nailing had significant knee pain at 1 year, including 25% of patients that were unable to kneel and 30% of patients that could not climb stairs without difficulty or at all [14]. A retrospective review by El Moumni et al. found that 23% of 75 patients treated with a retrograde femoral nail for diaphyseal fractures had persistent knee pain after 18 months [15]. Baltov at al reported outcomes of 111 patients treated with intramedullary nails for humerus fractures; 16% complained of significant shoulder pain with a mean follow up of 3.5 years [16]. The complexity of insertional pain has been described often with a combination of theories and anecdote but with little supporting evidence. In contrast to common beliefs that all “long term” insertion site pain is permanent, recent studies have revealed that certain causes may be linked to transient rather than permanent pain. The purposes of this review are to summarize the literature supporting causes of intramedullary nail insertional pain and delineate the surgical techniques that can help to avoid or address this problem.

Hardware prominence

The causal relationship between prominent hardware and insertional pain remains disputed. Lefaivre, et al. followed 56 patients for an average of 14 years and found self-reported knee pain and knee tenderness in physical examination were not correlated with nail prominence in radiographic images [4]. Similarly, Keating et al. found no correlation between knee pain and nail prominence in 107 patients [17]. In contrast Tahririan, et al. demonstrated that anterior or superior protrusion of the nail resulted in higher risk of developing knee pain [18]. Song et al. in their retrospective study of 45 patients found anterior nail prominence did not correlate with knee pain while superior nail prominence did [19]. Darabos et al. found in a similar retrospective review of 50 patients that those without insertional pain all had nails positioned at least 6 mm below the tibial plateau [20]. The abundance of retrospective literature on this topic has revealed no clear causal relationships between nail position and knee pain.

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http://dx.doi.org/10.1016/j.injury.2017.04.029
0020-1383/

Correlation between femoral nail hardware prominence and pain has also been examined retrospectively. Regardless of technique used in femoral nailing (antegrade piriformis, antegrade trochanteric, or retrograde), pain from hardware prominence is most commonly attributed to proximal and distal interlocking screws. Dodenhoff et al. found no significant relationship between antegrade nail tip prominence and pain in femoral nailing; however, pain from prominent proximal interlocking screws resolved with screw removal [21]. In retrograde femoral nailing, a prominent nail tip can impinge on the patellar tendon and the patellar articular surface. The incidence of retrograde femoral nail prominence has decreased with advances in surgical technique and improved implant technology. Similar to antegrade femoral nailing, protrusion of interlocking screws is the most common cause of knee pain related to retrograde femoral nailing [22].

Humeral nails are most commonly inserted using an antegrade technique. Common causes of insertion site pain at the shoulder are lateral migration of the nail, loss of fixation of proximal interlocking screws, and prominence of the nail under (or through) the rotator cuff. [23–27].

Treatment of symptomatic prominent hardware is generally elective implant removal if the patient decides their pain is substantial enough to warrant the procedure. Pain relief following hardware removal is inconsistent [17,28–31], and causation between prominent hardware and pain remains unclear [4]. Therefore, patients should be made aware preoperatively of the variable success with pain relief after removal.

Heterotopic ossification

Formation of heterotopic bone near the nail insertion site can also contribute to persistent pain. Dodenhoff et al., reported a 30% incidence of heterotopic ossification in antegrade femoral nailing, and of those patients, 88% had pain [21]. Other groups have reported incidences of heterotopic ossification in antegrade femoral nailing ranging from 48 to 60% [32,33]. Heterotopic ossification following tibial nailing is less common [17,34–36]. Insertion-related heterotopic ossification has been described in the patellar tendon of patients treated with a transtendinous approach. Antegrade humeral nailing is rarely associated with the development of heterotopic ossification, but it has been reported. [37]. Bone morphogenetic protein invokes heterotopic bone formation by in regional mesenchymal stem cells (MSCs) [38]. Similarly, reaming debris containing MSCs left in soft tissues may increase the risk of heterotopic ossification. Furlong et al. found that heterotopic ossification occurred in 35.7% cases with reamed antegrade femoral nailing, compared to 9.4% in the unreamed group [39]. In contrast, Brumback et el found no differences in the severity of heterotopic ossification after focused irrigation in surrounding tissues after nailing [33]. It is possible that debris is further embedded by high pressure irrigation [40,41]. It is likely that soft tissue injury from surgical dissection and osteogenic reaming debris both contribute to formation of heterotopic ossification in long bone IM nailing. Therefore, we recommend a meticulous surgical approach, utilization of soft tissue protectors including appropriate trocars, and removal of as much reaming debris as possible before it spread throughout the wound and embedded in the soft tissues.

Poor starting point/Soft tissue irritation

The location of intramedullary nail insertion point is critical because of the potential deleterious effects on the surrounding local tissue. A cadaveric study by Tornetta et al. demonstrated that the safe zone for the tibial nail starting point is located 4.4 mm lateral to the midline of the plateau and has a footprint from 12.6 to 22.9 mm in width [42]. Keeping the starting point within the described safe zone avoids injury to the menisci and intermeniscal ligament. Injury to these structures may result in persistent pain after intramedullary nailing. Ellman et al. reported a case of an anterior medial meniscal root tear after intramedullary tibial nailing and resulting persistent knee pain until the tear was repaired [43]. We believe iatrogenic meniscal injuries are under-reported as recently reviewed in a cadaveric study by Tornetta et al. They reported 20% intra-articular structural damage and 30% subjacent location of nail in relation to one of the menisci [42]. Many different surgical techniques have been described for tibial nailing and conflicting evidence exists regarding whether there is an advantage among different surgical approaches in regard to minimizing insertion-related knee pain. The transtendinous approach was thought to be the cause of knee pain from the development of fibrous scar tissue; however multiple studies have refuted this [17]. More recent evidence has cast doubt on the causal link between different approaches and knee pain [18,30,44]. Iatrogenic injury to the infrapatellar fat pad and the infrapatellar branch of the saphenous nerve in the medial parapatellar or the transtendinous approach may be a cause of knee pain. Weil et al. performed a retrospective review of 78 patients with tibia fractures treated with a reamed intramedullary nail using a modified lateral approach and found 19% of patients still had anterior knee pain [45]. A prospective study of 37 fractures treated with a suprapatellar approach by Sanders et al. reported no anterior knee pain [10]. The effect of instrumentation on the articular cartilage of the patellofemoral joint is still under investigation. Chan et al. recently reported the results of a randomized controlled pilot study comparing infrapatellar and suprapatellar approaches for tibial nail insertion. Of the 25 patients that completed the 12 month follow-up, 11 were treated with the suprapatellar approach, which included pre- and post-nail patellofemoral arthroscopy and a MRI at one year. There were no significant differences in knee pain or function between the two groups. In addition, there was a lack of correlation between the three patients with post-nail articular cartilage changes and patellofemoral pain at one year [46].

It is unusual for a poor starting point in antegrade femoral nailing to cause insertional pain, but there may be a correlation with poor fracture reduction, especially in proximal fractures. In retrograde femoral nailing, a poor starting point with sagittal plane malposition can damage the cruciate ligaments or trochlear side of the patellofemoral joint. Combined with an incompletely seated nail, this can lead to impingement on the patellar articular surface in knee flexion [47,48]. The traditional starting point for antegrade humeral nails is located at the medial edge of the greater tuberosity. This location is near the hypovascular zone of the rotator cuff insertion and may lead to injury and fibrosis of the supraspinatus tendon, contributing to shoulder pain [23,49]. Recently, a relatively medial starting point was proposed and demonstrated improved outcomes [50–52]. Clearly, locating the appropriate nail starting point while remain mindful of the local anatomy can minimize iatrogenic insertional pain.

Implant instability/Persistent fracture micromotion

Activities of daily living exert forces leading to elastic strains in the femur and tibia. IM implants affect elastic strain and may contribute to hardware pain [53,54]. For example, cementless femoral prostheses have been causally linked to thigh pain secondary to changes in proximal femur strain. In patients with proximal femur fractures, Li et al. found that patients treated with long cephalmedullary nails had significantly less hip pain than those with short nails in a study involving 156 patients [55]. That finding further supports the notion that an increase in flexural