■ ASPECTS OF CURRENT MANAGEMENT

Incidence and aetiology of anterior knee pain after intramedullary nailing of the femur and tibia

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Intramedullary nailing is considered to be the optimum treatment for fractures of the long bones of the lower limbs and various studies have been published describing the functional outcome of both reamed and unreamed nailing.¹⁻¹⁵ Several complications have been described including infection,^{2,13,14} compartment syndrome,¹⁶⁻²⁹ deep-vein thrombosis,³⁰⁻³² thermal necrosis of the bone with alteration of its endosteal architecture,³³⁻⁴⁰ failure of the metalwork^{16,20,22,23,27} and malunion and non-union of the fracture.^{2,3,6,15,41-44} However, one of the most common problems associated with tibial primarily, and retrograde femoral nailing secondarily, is chronic anterior knee pain.^{15,43,45-51} This can be an important handicap for the patient, affecting his employment and daily or leisure activities. Its incidence has been reported to be as high as 86%.⁵² It may be present even in patients who have an intact knee as with antegrade femoral nailing.^{7,15,30,43,44,51,53,54} Its aetiology is unclear, but a multifactorial origin has been suggested.

We have carried out a comprehensive review of the literature in order to determine the incidence of this complication, understand its pathophysiology and establish some recommendations and guidelines which may reduce its prevalence.

Materials and Methods

We undertook a Medline search between January 1990 and March 2005 using the following keywords and MeSH (Medline/Pub Med's Subject Headings article indexing terminology): 'femoral/tibial nailing and knee pain', 'antegrade/retrograde femoral nailing and knee pain', 'anterior knee pain after intramedullary nailing', 'long-term complications after intramedullary nailing' and 'knee pain'.

The material retrieved included studies and reviews in which knee pain after the peri-operative period was mentioned as being one of the complications of femoral or tibial intramedullary nailing. Studies used as references in these papers were also reviewed and assessed.

From each study the incidence of anterior knee pain, the period of follow-up, the approach used, the attributed cause of the pain by the author/s, the effect of removal of the nail and the outcome were recorded and analysed.

Statistical analysis. This was performed using SPSS for Windows software (version 11.0; SPSS Inc., Chicago, Illinois). Student's *t*-test, the chi-squared test and Pearson correlation coefficients were used to assess statistical significance which was assumed to be at the level of $p < 0.05$.

Results

We reviewed 84 articles, of which 43 were suitable for critical analysis; eight referred to knee pain after antegrade femoral nailing (AFN),^{7,15,30,43,44,51,53,54} 15 to retrograde femoral nailing (RFN)^{32,42-44,46,49,53-61} and 20 to tibial nailing (TN).^{1,5,8,11,12,22,45,47,48,50,52,62-70} No aetiology was proposed for the origin of the pain in four of the eight studies in the AFN group,^{7,44,53,54} six of 15 in the RFN group^{42,44,54,58,60,61} and six of 20 in the TN group.^{1,8,22,64,65,67}

Antegrade femoral nailing. In this group, there were five retrospective^{7,15,30,44,51} and three prospective studies^{43,53,54} describing a total of 1063 patients. Of these, 1011 (95.1%) had a reamed nailing. The mean follow-up period was 18.3 months (29.1 weeks⁴³ to 45.7 months⁵¹). The mean incidence of knee pain was 18.6% at the end of follow-up, ranging between 8.7%⁴³ and 37%.⁵¹ Only four authors gave information about the localisation and aetiology of the knee pain. The site of the locking screw was mentioned as well as diffuse femoral pain from the presence of the implant in the medullary canal or from prominence of the metalwork.^{15,30,43,51} In these studies there was no record of removal of implants in the symptomatic patients.

Retrograde femoral nailing. In this group, there were five retrospective studies,^{44,55,56,58,61} seven prospective studies,^{32,42,43,46,53,54,60} two case studies^{49,57} and one systematic review of the

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literature⁵⁹ giving a total of 516 fractures. The mean follow-up was 15.9 months (9⁵⁶ to 24⁴⁶). The mean incidence of knee pain was 25.6% (1.1%⁴³ to 55%⁵⁷) at the end of the follow-up. The most common causes of knee pain related to RFN were the protrusion of distal locking screws and impingement of the nail on the patellar tendon and/or the articular surface of the tibial plateau. In the very few cases in which the metalwork had been removed, there was an improvement of the symptoms in all of the six patients in the study of Gellman et al⁵⁵ and the one patient in that of Herscovici and Whiteman.⁴⁶

Tibial nailing. In this group, 11 retrospective^{11,22,45,47,48,50,62,63,65,66,70} and nine prospective studies^{1,5,8,12,52,64,67-69} had a total of 1469 fractures. Of the 1460 patients, 629 had symptoms of anterior knee pain independent of the approach used. The mean follow-up was 23.9 months (7.2⁶⁷ to 57⁶⁵). The mean incidence of anterior knee pain at the end of the follow-up was 47.4% (10%⁶⁷ to 86%⁵²). The most frequent cause of pain was the longitudinal division of the patellar tendon during the transtendinous approach, the entry point of the nail and the protrusion of the nail proximally. In 11 of the 20 studies the nail had been removed because of the pain,^{1,5,12,45,47,50,52,63,66-68} but in four no details were given regarding the outcome of removal.^{1,5,12,66} In eight studies the knee pain either persisted or the patients were partially relieved after removal of the nail^{11,45,47,50,52,63,67,68} and in two the pain was worse after this procedure.^{45,52} Information regarding the follow-up after extraction of the nail was available only from the study of Toivanen et al.⁵² In seven studies describing 228 patients, 111 noticed an improvement, or disappearance of the pain after removal of the nail.^{45,47,50,52,63,67,68}

General remarks. These findings indicate that anterior knee pain is more frequently related to tibial nailing and in particular to a transtendinous approach, protrusion of the nail or a painful point of entry. We attempted to correlate the incidence of knee pain to the type of approach used. In the RFN group of 222 fractures, 163 used the paratendinous approach (PTA)^{46,53,54,57,58,61} and 59 the transtendinous approach (TTA).^{44,55} In the TN group of 761 fractures, 211 had a PTA^{5,47,52} and 550 a TTA.^{45,47,52,63-68} We excluded seven studies from the RFN group^{32,43,44,49,56,59,60} and nine from the TN group since details of the approach were not given.^{1,8,11,12,22,50,62,69,70} Although an increased incidence would have been expected when a TTA was used because of the direct injury to the patellar tendon, in the RFN group the incidence of pain was significantly higher with the PTA ($p < 0.05$), which increases the risk of pain compared with the TTA ($p < 0.05$), odds ratio 2.38, 95% exact confidence interval (1.00 to 6.28). However, in the TN group there was no statistical difference between the approaches with respect to pain. However, definitive conclusions cannot be drawn from these observations since the samples and studies were not homogenous.

Knee function. This could not always be compared in the different studies since the authors used different scoring

systems. The SF-36 general health status form and the range of movement of the knee were used the most for quantifying the functional outcome.

The AFN group appeared to have the best outcome since there was no difference in the range of movement of the knee between the antegrade and retrograde groups.^{30,43,53,54} In the RFN group, the range of movement of the knee was on average $> 90^\circ$. Scholl and Jaffe⁶¹ found that 19% of their patients had restrictions in their daily or recreational activities. In the study of Handolin et al⁵⁶ the patients younger than 50 years had a normal range of movement. However, in the study of Sanders et al,⁶⁰ 50% of the patients with polytrauma were unable to return to their pre-injury activities and in that of Seifert et al,³² loss of extension was the main complaint of the patients with an average deficit of extension of 5° , but flexion to 110° . In the TN group, of the ten studies we could obtain complete information from, four had a favourable outcome with either normal movement or unrestricted daily activities,^{1,62,65,67} but in the other six^{8,12,45,47,52,69} a significant number of patients had their kneeling and recreational activities affected.

Discussion

The aetiology of anterior knee pain after intramedullary femoral or tibial nailing is uncertain, although there may be a combination of factors responsible.

Factors concerning the point of entry of the nail are matters of debate. The structures at risk within the joint are the medial meniscus, the lateral tibial plateau and the ligamentum transversum. Hernigou and Cohen⁷¹ and McConnell et al⁷² defined safe zones for insertion, easily localised by a pre-operative fluoroscopic measurement.⁷³ Although the danger of penetration of the articular surface is well known, the incidence of damage to the meniscus or cartilage of the tibial plateau is uncertain.⁷¹ We were not able to establish the incidence of knee pain in relation to meniscal or cartilaginous damage. However, for RFN, the optimum point of entry allows reduction of the fracture and spares the articular surface.⁷⁴ When the nail does not protrude, the entry portal is covered by fibrous scar tissue.^{42,49} The absence of pathological changes in the knee related to retrograde nailing has been confirmed arthroscopically by Moed et al⁴² and Gebhard et al.⁷⁵

Injury to the infrapatellar branch of the saphenous nerve can lead to anaesthesia, formation of a neuroma and reflex sympathetic dystrophy.^{76,77} A cadaver study by Tifford et al⁷⁸ defined the anatomical distribution of the branches of the saphenous nerve. These run almost perpendicular to the patellar tendon and it is the inferior branch which is more mobile in flexion of the knee.^{76,78} Horizontal incisions decrease the likelihood of nerve transection as the blade is parallel to the nerve.

Many authors have suggested that a TTA has more risks and is more often related to post-operative knee pain, because of splitting of the patellar tendon and the generously innervated retrotendinous fat pad and their repeated

injury during the operation.^{47,48,50,70} When PTA is used, the patellar tendon, the fat pad and the gliding tissues are not divided but are repeatedly traumatised by retractors and reamers. Independent of the approach used, injury to the tendon and soft tissues is unavoidable and we believe that the degree of this per-operative trauma is the most important causative factor.

Devitt et al⁷⁹ found arthroscopic evidence of chondromalacia patellae in a small number of patients with anterior knee pain after tibial nailing. They described an increase in force and contact pressure on the lateral facet when the medial PTA was used and on the medial facet with a TTA. Pressure increases were more notable with the latter and patellar chondral injury was more likely. Flexion of the knee to greater than 100° resulted in minimum contact between the introducer and the patella making pressure changes at the patellofemoral joint less likely. With retrograde nailing, research has shown no notable differences in the mean pressure, maximum pressure and contact area unless the nail is prominent in the patellofemoral joint.⁵⁷

Impingement of the infrapatellar fat pad with a total knee arthroplasty prosthesis and other knee pathologies and operations has been described.⁸⁰ The diagnosis can be confirmed intra-operatively by the presence of areas of necrosis and fibrosis of the fat pad.⁸⁰ It has not been described after intramedullary nailing, but a lesion of the fat pad could be related to a continuous irritation from protrusion of the nail or after per-operative trauma.

The proximal part of tibial nails can provoke trauma to the patellar tendon and the fat pad. Thick and disorganised tendon, reactive synovitis of the fat pad and calcification have been described in symptomatic patients with the tibial nail *in situ*.⁶⁸ MRI in patients with persistent pain after removal of the nail has shown patellar tendonitis, fibrosis and chondropathy, and irregular fibrosis of the fat pad.⁶⁸ However, Vaisto et al,⁸¹ in a prospective ultrasound study, found no difference in the ultrasonic appearances of the patellar tendons of symptomatic and asymptomatic patients, independent of the approach used.

Knee pain with antegrade femoral intramedullary nails, in which the distal end is covered by the bone, can be caused by the locking screws impinging with the soft tissues and the iliotibial band. Retrograde femoral nails can impinge on the inferior pole of the patella or the tibial plateau.^{32,55} This damage can be caused by nail protrusion from incorrect technique, or from incorrect fracture reduction with insufficient countersinking. It seems that the antegrade femoral nail is related to pain in the hip and proximal thigh, whereas screws inserted around the femoral condyles cause more symptoms in retrograde nailing.⁴³ Tibial nails can migrate towards the tibial plateau and become symptomatic, even if they are locked proximally and distally, most probably because of osteoporosis.⁶⁹

Anterior knee pain has also been attributed to weakness of the thigh muscles. Neuromuscular inhibition of quadri-

ceps and gastrocnemius occurs after knee injury, lower-limb trauma, extensor mechanism injury and reduced weight-bearing. Tibial nails should be positioned in a manner which minimises trauma to the extensor mechanism of the knee.⁸² It has been suggested that pain causes reflex inhibition of quadriceps with subsequent atrophy and/or aplasia.⁸³ EMG studies have shown a modification of neuromuscular control of quadriceps in patients with anterior knee pain.⁸⁴ We believe that weakness of thigh muscles is the result and not the cause of the anterior knee pain, as others have suggested.⁵³ Vaisto et al¹² observed that anterior knee pain after intramedullary nailing of fractures of the tibia may be related to deficiencies in the strength of the knee flexors. A 13% deficit in the strength of knee flexion was correlated with chronic anterior knee pain.

Gender- and age-related differences have also been given some consideration. Vaisto et al¹² noted that women were more symptomatic than men and had a longer hospital stay after tibial nailing. The reason is unknown but anthropometric and anatomical differences were suggested as causative factors.¹²

The presence of the implant in the medullary canal has also been considered to be the source of anterior knee pain. Bending of the femur during athletic activities is part of the normal elastic behaviour of the leg and an intramedullary nail may interfere with this.⁸⁵ The bending strain exerted by the proximal part of a tibial nail on the bone could be another explanation for anterior knee pain.⁷¹

Tissue lesions which are not seen macroscopically or after plain radiography can be related to anterior knee pain. There have been studies reporting lesions to the collateral ligaments, cruciate ligaments, menisci, articular cartilage and bone after acute trauma to the joint or following femoral and tibial fractures. These lesions have been assessed by examination under anaesthesia,^{86,87} arthroscopy⁸⁸⁻⁹⁰ and MRI.⁹¹⁻⁹³ Dickson et al⁹² found that 30% of bone contusions were situated in the tibia and 63% in the femur, equally divided between medial and lateral compartments. Bone bruises can be identified by MRI only and are increasingly being acknowledged as a source of persistent symptoms. The incidence of ligamentous laxity of the knee and meniscal injuries have each been reported to be approximately 49% after femoral fracture on arthroscopic evaluation.⁹⁰ Examination under anaesthesia and arthroscopy after intramedullary femoral nailing had positive findings in 55% of the patients.⁸⁸

Recommendations – Guidelines

Based on this survey the following recommendations can be made:

- 1) The skin incision should be placed away from the area involved in kneeling, particularly in patients who have to kneel daily because of the nature of their work. Karladani and Styf⁹⁴ described a percutaneous approach for the tibial nailing in which the skin incision was perpendicular to the joint line and was situated either on the medial or lateral

side of the patella, away from the kneeling area and from the infrapatellar branches of the saphenous nerve.

2) Since the anatomical position of the infrapatellar branch of the saphenous nerve cannot be known in advance, horizontal incisions or percutaneous approaches should be favoured, although in some cases a longitudinal incision is required. Limited-extension incisions could minimise the risk and the incidence of injury to this nerve.

3) Protrusion of the nail should be avoided. The implant should be adequately countersunk and the appropriate design chosen regarding its profile and position of the locking screws.

4) The length of the locking screws must be carefully checked to avoid protrusion and irritation of the soft tissues.

5) Injury to the patellar tendon, fat pad and gliding tissues should be avoided by the delicate use of the instruments and by employing tissue protectors.

6) Flexion of the knee to an angle greater than 100° should give minimum contact between the introducer and the patella, making the pressure changes at the patellofemoral joint less likely.

Supplementary material

Tables a to i are available with the electronic version of this article on our website at www.jbjs.org.uk

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