Total knee arthroplasty (TKA) is an effective procedure for decreasing pain, improving functional capability, and increasing the overall quality of life for thousands of people with chronic knee osteoarthritis. Although patient outcomes and satisfaction remain high, a substantial percentage of patients report residual pain after TKA. Sources of postoperative pain include intra- and extra-articular etiologies as well as factors unrelated to the implants themselves. A patient-centered approach to the painful TKA may aid clinicians in diagnosing and treating patients with intra-articular causes of pain after TKA. A thorough understanding of the mechanisms involved may lead to improved preoperative planning and patient selection, ultimately decreasing the number of patients with less than optimal postoperative outcomes.

**Abstract**

Total knee arthroplasty (TKA) is an effective procedure for decreasing pain, improving functional capability, and increasing the overall quality of life for thousands of people with chronic knee osteoarthritis. Although patient outcomes and satisfaction remain high, a substantial percentage of patients report residual pain after TKA. Sources of postoperative pain include intra- and extra-articular etiologies as well as factors unrelated to the implants themselves. A patient-centered approach to the painful TKA may aid clinicians in diagnosing and treating patients with intra-articular causes of pain after TKA. A thorough understanding of the mechanisms involved may lead to improved preoperative planning and patient selection, ultimately decreasing the number of patients with less than optimal postoperative outcomes.

**Hospital charges alone are estimated to be $2.7 billion annually and are expected to exceed $13 billion annually by 2030.**

The goals of TKA are to decrease pain, improve function, and increase quality of life. The leading cause of postoperative dissatisfaction is residual pain. Intra-articular sources of pain may be multifactorial, with the most common causes including (but not limited to) infection, implant loosening, and component malalignment or malpositioning. Infection is the most common intra-articular cause of pain after TKA and should be ruled out first. Component malalignment can cause many extra-articular and intra-articular derangements that contribute to knee pain. The ultimate treatment in these
Implant-Related Issues

Aseptic Component Loosening

Aseptic loosening remains a frequent cause of failure in primary TKA, despite improved implant designs. Pain is typically mechanical in nature and frequently described as “start-up pain.” Increased load transfer from more constrained implants, a high body mass index, varus alignment, and malrotation have been shown to be contributing factors to implant loosening.

Polyethylene wear resulting in osteolysis has been cited as an additional cause of implant loosening. Despite improvements in prosthetic materials, wear inevitably occurs with a release of inflammatory cytokines into the surrounding tissues. Polyethylene wear results from mechanical damage to the articulating surface of the implant and creates wear particles that can lead to late failure. Osteolysis occurs after the release of proinflammatory cytokines (interleukin [IL]-1, IL-6, and tumor necrosis factor-α) triggered by these wear particles via activation of peri-implant macrophages.

Although loosening of the femoral, tibial, or patellar components may occur, tibial loosening is most commonly reported. Aseptic loosening is more commonly seen as a late mode of failure, accounting for 16.9% of failures at TKA follow-ups of less than 2 years compared with 34.4% of failures requiring revision after 2 years. Malalignment and wear are frequently responsible for late loosening, whereas early failures have been associated with cementless implants, minimally invasive techniques, and certain specific implant designs.

Diagnosis

Patients may report pain that occurs after rising from a sitting position that improves after ambulation because the prosthesis settles into a more secure position; this is so-called start-up pain. Over time, increased implant displacement results in worsening pain and bone defects. If the patient was initially pain free and pain did not occur until months or years after surgery, component loosening or failure should be considered. Physical examination findings are often nonspecific, although instability and an effusion are common findings.

Routine standing AP and lateral radiographs should be obtained to assess component fixation, positioning, and sizing, as well as periprosthetic osteolysis. Complete, circumferential radioluencies are usually diagnostic of component loosening but may not be present. Although radiolucency at the bone-cement interface may suggest a loss of fixation, the importance of an incomplete radiolucency remains unclear. Serial radiographs are often extremely helpful in determining if radioluencies are progressive or if implant migration has occurred. Fluoroscopic evaluation can be helpful in obtaining a perfect lateral view, which may be particularly helpful when assessing the interface of cementless implants. In cemented implants, complete or thick radiolucent lines greater than 2 mm may indicate loosening. In cementless implants, any line between the bone and the implant suggests a lack of bony ingrowth and may signify loosening if...
If osteolysis is suspected, it should be evaluated with CT because plain radiographs often underestimate the size of the osteolytic lesion.34

**Treatment**

The treatment of aseptic loosening involves revision TKA. Although only the component affected by loosening must be revised, revision of both components is performed if (1) evidence of simultaneous loosening is present, (2) alignment or rotation is suboptimal, (3) component retention hinders exposure, or (4) increased constraint is needed. In all TKA revisions for loosening, it is imperative that all components, including the patella, be assessed and revised if necessary.

**Instability**

Instability is frequently cited as a major cause of revision TKA, accounting for 10% to 28.9% of primary TKA failures.5-7,11,13,35,36 Instability causes pain through overloading of the supporting soft-tissue sleeves, with activation of mechanoreceptors and pain fibers in capsular and ligamentous structures. Instability may cause both early and late failures.5,6 Early failure related to instability may be associated with trauma and/or surgical technique, including suboptimal alignment or positioning, improper balancing of the flexion-extension gaps, and early medial collateral ligament or posterior collateral ligament (PCL) rupture.13 Patellofemoral instability may be caused by component malrotation. Late failure related to instability can be secondary to polyethylene wear and/or implant loosening.

Instability can be classified as flexion, midflexion, or extension in the coronal plane or global instability, which can occur in the coronal and/or sagittal planes.37 Coronal plane instability can be caused by ligament imbalance, ligament rupture, or component malalignment. Sagittal plane instability typically occurs in flexion and can be attributed to a flexion gap that is too large secondary to improper component size or positioning, an improperly balanced or incompetent PCL in cruciate-retaining designs, or excessive tibial slope.37

**Diagnosis**

A patient’s subjective account of instability may actually be the result of flexion contracture, quadriceps weakness, or a complication related to the patella.13,35,36 Knowledge of risk factors for instability, including neuromuscular disease, adjacent joint deformities, and obesity, is essential for a proper diagnosis because these factors can alter the treatment plan.36 Combined instability in extension and flexion has been most commonly cited, but isolated instability in flexion or extension also can occur.38 Patients with instability often report that the prosthetic components feel as if they will not support their weight. If a patient was initially pain free after TKA and pain did not appear until months or years after surgery, late ligamentous instability, asymmetric polyethylene wear, or implant loosening should be considered.29

Patients with flexion instability may report unsteadiness or anterior knee pain while ascending or descending stairs or when rising from a chair.13,36,39 The physical examination should include a gait evaluation and an
examination of the collateral ligaments for varus-valgus laxity in extension, midflexion, and 90° of flexion. Anterior and posterior drawer tests should be used to evaluate AP joint laxity, with particular focus on performing these tests with the knee flexed to 90° to fully evaluate flexion laxity. This is especially important in patients with a posterior-stabilized implant because flexion instability can cause the femoral cam to slide over the polyethylene post, leading to instability and pain. The patient should be asked to sit with his or her knee hanging unsupported; this can reveal a large flexion gap.

Varus or valgus knee alignment may be a sign of ligamentous instability. When bearing weight, patients with hyperextension may have PCL insufficiency or excessive wear of the posterior aspect of the polyethylene insert. With coronal plane instability, a patient’s gait pattern may show medial or lateral thrust. Sagittal plane instability can occur with tenderness over the pes anserinus tendons and positive posterior drawer or posterior sag tests. It is important to evaluate the PCL in cruciate-retaining implants; a posterior or sag test or a quadriceps active test may reveal instability. With posterior-stabilized implants, it is important to check the competency of the post against the cam and note the presence of any subluxation over the cam if the knee is loose in flexion.

AP short- and full-length weight-bearing radiographs and lateral radiographs with the knee in full extension and flexion should be obtained both preoperatively and postoperatively, with careful attention paid to both the mechanical and the anatomic axes as well as component positioning. Sagittal plane instability may be evident on posterior stress radiographs with the knee in 90° of flexion; this may reveal evidence of posterior joint subluxation. If ligament or tendon damage is suspected, studies have shown that MRI may be diagnostically beneficial if the appropriate software is used to reduce artifact from the metallic implants.

**Treatment**

Revision is generally necessary for instability because nonsurgical treatment, including bracing and physical therapy, are rarely effective. Achieving proper alignment and eliminating destabilizing forces are necessary; the minimum amount of constraint needed to establish stability should be used. Constraint is typically required only if the collateral ligaments are insufficient. Instability secondary to overresection of the distal femur should be managed with augments or bone graft to re-create the joint line and fill the extension space. PCL insufficiency in a cruciate-retaining implant necessitates conversion to a posterior-stabilized implant. Constrained articulations provide varus-valgus constraint as well as resistance against dislocation of the knee secondary to the femur “jumping” the polyethylene post but may be associated with increased stress at the prosthetic interfaces and a higher risk of subsequent implant loosening. However, these articulations may be required in cases where a severe flexion-extension mismatch is present (Figure 2) or if the medial or lateral ligamentous structures are incompetent. In some instances, particularly with a very large flexion gap or if recurvatum is present that cannot be corrected, a hinged implant may be necessary if the laxity is so great that a nonlinked constrained implant will dislocate secondary to the femoral component jumping the polyethylene post.

**Improper Gap Balancing**

Ligament balancing is essential for reestablishing proper knee stability. Pain in full extension and/or a flexion contracture in which the patient is comfortable until the knee is brought into terminal extension may be indicators of an overstuffed extension space.

Full-flexion pain occurs when a patient attempts to flex his or her knee beyond the soft-tissue, bony, or prosthetic limit and may indicate posterior impingement or overstuffing of flexion or patellofemoral spaces. Flexion instability results when the flexion gap is larger than the extension gap, and it is often a result of an undersized implant, an incompetent PCL, or excessive tibial slope (Table 1). Symmetric extension instability is less common than asymmetric extension instability, and it is frequently attributed to excessive bone removal from the distal femur that results in an inadequately filled extension space. Excessive tibial resection will affect the flexion and extension spaces equally and cause global instability and, in some cases, recurvatum.

On physical examination, varus-valgus instability testing at 30° of flexion is needed to diagnose an elevated joint line, which will appear stable at both 90° of flexion and full extension.

**Component Malalignment**

Correct component positioning is necessary to prevent instability, pain, and improper wear that can decrease component survivorship after TKA.

Improper positioning often causes pain after TKA and frequently is cited as a common indication for revision TKA.
Improper alignment has been linked to both early and late failure. A study by Sharkey et al. reported that improper alignment was responsible for 11.9% of early and 12.2% of the late failures. Concomitant mechanisms of failure likely account for the discrepancy in timing, with rotational malalignment causing instability reported to cause early failure, whereas malalignment leading to aseptic loosening represents a mechanism of late failure.

Neutral coronal alignment has been proposed as an important component of TKA in early studies of compressive forces in TKA; later studies have found higher 10-year survival rates in knees in neutral alignment. Although higher rates of failure have been observed with substantial preoperative deformity, this likely reflects the increased difficulty of obtaining neutral postoperative alignment in these patients.

Rotational malalignment, specifically excessive internal rotation, has been linked to pain and failure after primary TKA, with an increased prevalence of patellofemoral complications and anterior knee pain. A recent study found that internal rotational malalignment of the tibial and femoral components individually as well as combined component rotation mismatch and combined component rotation were associated with unexplained pain after primary TKA. In addition, studies have consistently found increased pain and decreased patient satisfaction when CT shows more than 3° of internal rotation of tibial and/or femoral components.

Diagnosis

The absence of a pain-free interval after TKA should prompt an investigation into prosthetic malalignment after a negative workup for infection. Varus or valgus alignment also may indicate malpositioning. Long-leg, standing radiographs are optimal for assessing alignment. Component malalignment in the sagittal plane is evident on lateral radiographs, with evidence of either excessive or inadequate tibial slope or flexion/extension of the femoral component. To assess component malalignment in the transverse plane, a Merchant view can be used to assess

<table>
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<tr>
<th>Flexion</th>
<th>Management: Normal Extension</th>
<th>Management: Tight Extension</th>
<th>Management: Loose Extension</th>
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<tbody>
<tr>
<td>Normal</td>
<td>Nothing</td>
<td>Resect distal femur</td>
<td>Distal femoral augmentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Release posterior capsule</td>
<td></td>
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<tr>
<td>Tight</td>
<td>Resect posterior femur</td>
<td>Downsize polyethylene insert</td>
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<td></td>
<td>Shift femoral component</td>
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<td>Loose</td>
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<tr>
<td></td>
<td>Posterior augmentation</td>
<td></td>
<td>Larger polyethylene insert</td>
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*The management of gap imbalance is etiology specific.*

Diagnosis

The absence of a pain-free interval after TKA should prompt an investigation into prosthetic malalignment after a negative workup for infection. Varus or valgus alignment also may indicate malpositioning. Long-leg, standing radiographs are optimal for assessing alignment. Component malalignment in the sagittal plane is evident on lateral radiographs, with evidence of either excessive or inadequate tibial slope or flexion/extension of the femoral component. To assess component malalignment in the transverse plane, a Merchant view can be used to assess
the position of the patella in the prosthetic groove (Figure 3). This view is important because subluxation of the patella with resulting pain and stiffness in flexion may impair proper assessment of the femoral component; rotational alignment can be most accurately assessed with CT\(^\text{58,69}\) (William Mihalko, MD, Chicago, IL, unpublished data presented at the American Academy of Orthopaedic Surgeons annual meeting, 2013).

**Figure 3**

A, Merchant view of component alignment shows a patella sitting lateral to the prosthetic groove. Malrotation of the femoral component caused patellar tilt and subluxation. On a Merchant view, it is difficult to assess the component position in the transverse plane and if there is internal rotation of the femoral component causing the subluxation. B, Illustration shows important axes for correct component alignment. Line A shows the long axis of the femur. Line B shows the transepicondylar axis. Line C shows the posterior condylar axis.

**Figure 4**

Problems with rotational alignment may lead to patellar maltracking. A, CT scan showing rotational alignment of the patella and the femur in relationship to the epicondylar and posterior condylar axes. B, CT scan showing rotational alignment of the tibia as related to the tibial tubercle.

surgery should be considered.\(^\text{70}\) Femoral component rotation parallel to the epicondylar axis yields the best patellar tracking and reduces patellofemoral shear forces in early flexion.\(^\text{71}\)

**Anterior Knee Pain**

Pain within the patellofemoral joint and problems with the extensor mechanism after TKA are common, with a prevalence of 12% to 26% after primary TKA.\(^\text{72,73}\) Pain related to the patellofemoral joint is the primary indication for revision surgery not mandated by an infectious cause.\(^\text{72}\) Patellar subluxation or dislocation, patellar component wear, patellar necrosis, and fracture are all reported causes of anterior knee pain after TKA.\(^\text{72}\)

**Patellar Maltracking**

Patellar maltracking is a common cause of early complications after TKA.\(^\text{58}\) It is generally related to malrotation of the femoral and tibial components or asymmetric patellar resection and positioning (William Mihalko, MD, Chicago, IL, unpublished data presented at the American Academy of Orthopaedic Surgeons annual meeting, 2013) (Figure 4). An intraoperative trial reduction with “no thumb” tracking through full flexion can ensure the patella rides normally within the trochlear groove.\(^\text{58}\)

**Asymmetric Patellar Resection**

Asymmetric resection of the patella during TKA correlates with anterior knee pain from overstuffing, bony impingement, and patellar maltracking.\(^\text{73}\) Asymmetric resurfacing of the patella occurs in approximately 10% of TKA patients and is defined as a difference greater than 2 mm in thickness measured 15 mm from the medial and lateral edges.\(^\text{52,74,76}\) For the average patellar
width of 46 mm, this 2-mm difference correlates to a resection angle of 7°.73,77

Preferential resurfacing of the lateral facet with underresection of the medial facet can lead to asymmetric resection.75 The diagnosis may be elusive because a patient can present with tilt without subluxation. The depth of resection is important to consider because too little resection can increase patellar thickness, an alteration in the biomechanics of the quadriceps, and limited flexion. Excessive resection can lead to a thin and mechanically weak patella that is prone to fracture.78-80 A thickness of less than 12 to 13 mm should be avoided.80 The medial and lateral edges of the quadriceps tendon proximally and the lateral edge of the patellar tendon distally can be used as landmarks to control the cut in the coronal plane. Using these landmarks allows for consistent cuts, with smaller deviations in depth and slope.76

**Patellar Overstuffing**

Several studies have reported a link between patellar overstuffing and pain after primary TKA.81-85 Underresection of the anterior femur, leading to a greater anteroposterior dimension compared with the implant or an oversized femoral implant, can cause patellar overstuffing.81,82 Because the patellar retinaculum is relatively fixed in length, increasing the anteroposterior length of the patella or femur may result in poor outcomes from increased tension on the lateral retinaculum and substantially limit passive knee flexion.81,82 As little as 2 mm augmentation of the trochlear groove can substantially affect range of motion (ROM).82 Careful attention must be paid to anterior femoral resection to ensure the anterior cut is placed optimally to avoid notching.

**Metal Hypersensitivity**

Metal ions interact with native proteins in the body to create metal-protein complexes that can cause a type IV hypersensitivity response (pain, redness, and itching) in predisposed individuals (10% to 17% of the population).86-88 In evaluating hypersensitivity reactions, patch testing of the skin and lymphocyte transformation testing have been used to predict a patient’s susceptibility to metal allergic reactions. The utility of patch testing of the skin remains questionable, and further studies are needed to determine its usefulness because cutaneous hypersensitivity may not correlate with reactivity of the deeper tissues.84,85,89 Lymphocyte transformation testing exposes a patient’s lymphocytes to metallic particles and may better correlate with deep sensitivity; however, its usefulness is limited by the specificity of the allergens tested and the few facilities that can perform the test.89-91 Also, the clinical implications of lymphocyte reactivity are unknown. If revision TKA is considered in patients with a known hypersensitivity to metals (the most common of which is nickel), the authors recommend using an implant that does not contain nickel, such as those made of ceramicized metal or titanium that has been surface hardened.91

**Nonimplant-Related Issues**

**Snapping Popliteus Tendon**

In up to 2.7% of TKAs, the popliteus tendon is a source of postoperative knee pain.83 It is thought that the popliteus tendon may be irritated by either a remaining osteophyte or an overhang of the posterior lateral aspect of the prosthetic femoral condyle. Symptoms often include a snapping sensation on the lateral joint line, which may be audible.84 Tenderness to palpation occurs over the femoral insertion of the popliteus tendon. Prior to the availability of gender-specific knee implants, this complication was more common in female patients who required a larger femoral prosthesis in the anteroposterior plane, resulting in mediolateral overhang that allowed impingement of the popliteus tendon.83

Retaining the popliteus tendon is controversial in a posterior-stabilized TKA because some physicians report that the tendon has no meaningful function after arthroplasty and can be a source of discomfort. In the native knee, the popliteus tendon functions to internally rotate the tibia on the femur as the knee flexes.85 In a cadaver study, the popliteus tendon was shown to have a greater effect on the flexion gap compared with the extension gap. The popliteus tendon was most effective from 60° to 90° of flexion.92 However, in a study by Kesman et al,93 no observable difference was detected after TKAs in which the popliteus tendon was sectioned versus those where it was kept intact. Other investigators have reported decreased functional scores 2 to 3 years postoperatively after TKA in patients with an iatrogenically sectioned popliteus tendon.94

A snapping popliteus tendon usually can be diagnosed clinically. However, it has been suggested that the condition can be detected at the time of an initial TKA with the capsule closed.83 This early detection would allow prophylactic popliteus tendon release. The successful arthroscopic release of a snapping popliteus tendon months to years after the initial arthroplasty procedure has been described.84
Patellar Issues
Anterior knee pain is common in many individuals, both in those who have undergone TKA and those who have not. Substantial controversy exists regarding patellar resurfacing versus nonresurfacing during TKA. Patellar tracking is also a primary concern during TKA. Attempts to decrease the Q angle to minimize lateral subluxation and lateral tilting can cause postoperative symptoms. If the patellar component is placed too far medially or if there is a retained lateral osteophyte, the lateral aspect of the patella may impinge on the femoral condyle and cause pain. For a patient with a painful TKA postoperatively, lateral patellofemoral impingement should always be considered. The examination should include palpation of the lateral facet. Partial lateral facetectomy, combined in some cases with patellar revision if necessary, has been described as providing good results.

This chapter’s senior author (KJS) performs selective osteoclasis at the periphery, which forms a smooth transition from the patellar button to the remaining lateral patellar cortex. In addition, there may be selective scarring around the patella that causes postoperative pain. Thorpe et al defined three types of intra-articular fibrous bands around the patella that can cause dysfunction and pain. All were treated with arthroscopic lysis of adhesions and had excellent outcomes.

Arthrofibrosis
Arthrofibrosis is the excessive fibroblastic tissue healing response that results in a loss of motion, typically after knee trauma or surgery. Although stiffness is common after TKA, ROM will improve until up to 1 year postoperatively. However, certain patients will plateau or lose ROM during rehabilitation. These limitations in ROM can affect activities of daily living. Several authors have attempted to define arthrofibrosis based on a specific ROM, with most limits being defined as flexion of less than 70° to 75° and a loss of extension of 10° or greater. The incidence of arthrofibrosis after TKA has been reported at 3.7% to 12%. Loss of extension has been shown to increase the workload in the quadriceps (specifically to stabilize the weight-bearing flexed knee). The importance of arthrofibrosis is directly related to the ROM required to perform activities of daily living, with a minimum of 90° of flexion required for many activities. Laubenthal et al reported that the average knee motion required for climbing stairs normally was 83°, for sitting, 93°, for tying a shoe, 106°, and for lifting an object, 117°.

The etiology of arthrofibrosis is poorly understood and multifactorial. Factors contributing to postoperative stiffness include preoperative, intraoperative, and postoperative factors. Preoperative factors such as decreased initial ROM and an increasing body mass index contribute to the increased risk of postoperative stiffness. Component malalignment also has been cited as a risk factor for stiffness; however, this is not supported by a recent study. Three-dimensional CT assessment of component alignment was measured prospectively, comparing patients who required and did not require knee manipulation. No significant difference in component alignment was observed in this cohort. Postoperative factors implicated in arthrofibrosis include the timeliness of initiation of physical therapy and individual perception of pain.

Multimodal pain management has been suggested to decrease the incidence of arthrofibrosis. Lavernia et al reported that the incidence of arthrofibrosis decreased by 53% in those with treated with multimodal pain management and suggested that better pain control allowed patients to be more compliant with physical therapy and early motion. The treatment of arthrofibrosis includes early physical therapy, manipulation under anesthesia, and arthroscopic and open procedures for lysis of the adhesions.

Manipulation under anesthesia is the first choice in treating a stiff TKA. Indications for manipulation include failure to obtain 90° or greater flexion by 2 months postoperatively. The goal of manipulation is to obtain a ROM of 90° or greater. Physical therapy is initiated immediately, with most therapy appointments prearranged for the same day or the first postoperative day. Keating et al reported on a series 6,297 PCL-retaining knees; 113 knees (1.8%) required manipulation. The results showed patients at risk of requiring manipulation were younger (65 versus 71 years), less obese, and had less preoperative flexion. The authors found that manipulation was successful 90% of the time, with an average improvement of 35° that was maintained to 5 years. There was no significant difference in the outcomes of those treated with manipulation early (<12 weeks), the type of anesthesia (general or epidural), or the type of postoperative pain management (patient-controlled anesthesia or continuous epidural control). The complications of manipulation included a risk of fracture, component loosening, and the need for further surgery. Other reports suggest earlier manipulation is better, with most authors suggesting manipulation be performed at less than 6 to 12 weeks after TKA.
Another option for surgical treatment is an arthroscopic lysis of adhesions if the components are well fixed and appropriately sized and aligned. In this procedure, it is important to reestablish the medial and lateral gutters as well as the suprapatellar pouch and intercondylar notch. Careful, gentle arthroscopy is recommended, with plastic cannulas preferred to prevent scratching of the articular surface.108

In cases where component sizing, fixation, alignment, or rotation are not optimal, revision TKA is considered. Hartman et al109 reviewed their experience with revision TKA for stiffness in a series of 35 patients. At a mean of 55 months postoperatively, the mean improvement in ROM was 45°, with 75% of patients improving by at least 30°. The authors cautioned, however, that the risk of complications and additional interventions (such as manipulation under anesthesia) to achieve these results were substantial (nearly 50%). Most studies suggest that open arthrolysis and a modular exchange of the polyethylene liner is associated with poorer results110 because the underlying reasons for stiffness (including suboptimal ligament balance and component positioning) are not addressed; hence, the temptation to perform this type of intervention should be resisted.

**Recurrent Hemarthrosis**

After TKA, a rare but troublesome complication is recurrent hemarthrosis. The incidence is 0.1% to 1.6%.111 Hemarthrosis is thought to be caused by impingement of the hypervascular synovium between arthroplasty components, and, for this reason, it is often recurrent. Both early and late cases of hemarthrosis have been described. Arteriovenous fistulae, pseudoaneurysms, micromotion of the host bone-cement interface (loosening of the implant), pigmented villonodular synovitis, anticoagulation therapy, and infections have been reported.112-114

In a study of 30 patients by Kindsfater and Scott,115 the average interval from implantation until the first hemarthrosis averaged 24.2 months, and the average number of recurrences was 5.5. The initial management is nonsurgical, including rest, ice, elevation, and the discontinuation of anticoagulant therapy, if possible. The workup includes coagulation studies, duplex ultrasounds, and CT and/or MRI angiography. Joint aspiration is used to confirm the diagnosis and rule out infection. If hemarthrosis is refractory to nonsurgical measures, open or arthroscopic cauterization is routinely successful. Open synovectomy with polyethylene exchange to gain better access to the posterior knee has been recommended.115 Retrospective studies have shown better results with open synovectomy compared with arthroscopic measures.115 If recurrent hemarthrosis persists, another treatment option is selective coil embolization, which has an approximately 75% effectiveness rate.116

**Particulate-induced Synovitis**

Wear particles are generated in all arthroplasty settings. The most familiar presentation is osteolysis associated with polyethylene wear debris that causes aseptic loosening of implant components. This wear debris is phagocytosed by macrophage-stimulating and inflammatory responses that cause destruction of adjacent tissue. The synovium can be equally affected by the wear particles; this induces global synovitis. Patients have gradual pain and swelling with stable ligaments, maintained ROM, and diffuse tenderness. Radiographs are frequently negative for signs of osteolysis because symptoms may precede radiolucencies, and CT may be helpful for identifying earlier osteolytic lesions. The treatment of particulate-induced synovitis is aimed at the source of the accelerated wear and includes polyethylene exchange or component revision. It should be noted that previous reports of isolated tibial insert exchange for wear or instability have shown surprisingly poor results, with a survival rate of 63.5% at a 5.5-year follow-up.117,120

**Summary**

TKA is an extremely successful procedure with a low complication rate. However, with the average age of the US population increasing, the number of TKAs performed is expected to rise dramatically in the coming years. As the number of procedures increases, the incidence of pain after TKA also is expected to increase. It is important for orthopaedic surgeons to be familiar with the common causes of pain after TKA and have a standardized approach for these patients. A thorough understanding of the mechanisms causing pain after TKA may lead to improved preoperative planning and patient selection; this could ultimately decrease the number of overall complications.

**References**


