The role of isolated polyethylene exchange in total knee arthroplasty

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The use of modular total knee arthroplasty (TKA) implants allows surgeons to perform isolated tibial polyethylene insert exchange (IPE) while retaining well-fixed and stable components.

The purported advantages of IPE include preservation of bone stock, shorter operating time, less blood loss, faster rehabilitation and lower cost. However, the indications for IPE are limited.

IPE for wear and osteolysis has moderate success in the medium term but should be avoided in cases of accelerated wear. In selected cases, debridement and IPE for early infection can result in low morbidity with high success rates in the short term. IPE for arthrofibrosis has poor results.

IPE should be undertaken with caution and an institutional algorithm should be followed.

Keywords: total knee arthroplasty; revision; isolated polyethylene exchange

Introduction

Total knee arthroplasty (TKA) is a very successful operation that can deliver great patient satisfaction1,2 with good implant survivorship.3 Notwithstanding this, the number of revision TKAs is on the rise for a myriad of reasons, including surgical technique and patient selection.4 Midflexion instability owing to excessive joint line alterations, as well as poor patient selection for unicompartimental arthroplasty causing early failure, have contributed to a rise in the incidence of revision TKA. In the current literature, the most common reasons for revision TKA are aseptic loosening, usually as a result of wear, and infection.2,5-8

These, together with instability and stiffness, account for 80% to 90% of all revisions.5-8

Modularity for TKA was first introduced in the 1980s. It conferred a number of advantages, such as intra-operative flexibility, ability to use porous coating and stems, and the possibility for late liner exchange. Isolated polyethylene exchange (IPE) with retention of well-fixed components is an attractive option because of shorter operating time, less blood loss, preservation of bone stock and faster rehabilitation.9 The most common type of revision TKA in the United States until 2010 was all-component revision (35%).4 Femoral component revision accounted for 4% and tibial component revision accounted for 10%, while IPE accounted for 9% of all revisions.4 Partial revision appeared initially to have better functional outcomes than complete revisions.10 However, the failure rate was reported as being significantly higher for IPE.6,11

IPE has been reported for polyethylene wear, infection and arthrofibrosis. All the reports have been independent, unblinded series. To our knowledge, there is no randomised clinical trial that compares different revision surgery for failed TKA. The purpose of this article is to review the current literature and registry results, and outline an algorithm for the role of IPE in revision TKA.

IPE for wear and osteolysis

The number one cause for revision at five years after TKA is osteolysis from polyethylene wear.12 Abrasive and adhesive wear of polyethylene tibial inserts generates particulate debris that can lead to peri-prosthetic osteolysis. The use of modular components also contributes to this process of osteolysis via ‘backside’ wear. Accelerated polyethylene wear and extensive osteolysis can result in aseptic loosening, peri-prosthetic fractures, component failure and recurrent painful effusion.13 It is imperative to monitor
this process and intervene in a timely fashion to prevent more severe wear-related complications.

Patients may be asymptomatic early in the disease, but most will present with pain, swelling or acute synovitis. Serial radiographs, including oblique views,\(^1\) will be necessary to monitor the progression of the disease. CT scans are useful to assess the areas of osteolysis and MRI may be a more sensitive tool to detect osteolytic lesions.\(^1\) If the patient is relatively asymptomatic with minimal wear and osteolysis on plain radiographs, we recommend close follow-up to monitor for signs of progression. If the patient becomes symptomatic or the osteolysis is progressive, surgery is considered.

Patients with posterior-stabilised knee implants may also present with polyethylene tibial post fractures. The most likely failure mechanisms are anterior impingement and excessive wear of the tibial post, which then becomes a stress-riser of the post and cam articulation.\(^1\) Factors known to cause anterior tibial post impingement include femoral cam and tibial post designs that allow hyperextension of the knee, cement remnants at the notch of a posterior-stabilised TKA implant, a relatively larger extension gap than flexion gap, a flexed position of the femoral component in the sagittal axis and excessive posterior tibial slope. Therefore Callaghan et al suggested that the surgeon should avoid flexion of the femoral component and excess posterior tibial slope during proximal tibial resection.\(^1\) After the diagnosis has been established, revision of the polyethylene insert should be considered if the components are well fixed and in good sagittal and coronal alignment. Genu recurvatum should be addressed with the use of a brace, if necessary. A systematic review by Lachiewicz concluded that tibial post fracture is a relatively uncommon complication after posterior-stabilised TKA that usually is treated successfully with IPE.\(^1\) However, he mentioned that the low quality of available literature makes it difficult to recommend a specific treatment protocol.

IPE with bone grafting is an attractive option for well-fixed and well-positioned components.\(^1\) Results of IPE without bone grafting from earlier studies have been dismal. Kapadia et al reported 33% (8 of 24) failures at a mean of four years,\(^2\) while Engh et al reported a failure rate of 25% in less than five years.\(^3\) Sharkey et al reported 29% revisions of IPE at a mean of three years,\(^2\) and 30% of the unrevised cases had persistent pain. However, use of bone graft (autologous or allograft) with IPE for well-fixed implants yields better results. In a more recent paper, Callaghan et al noted that 84.6% and 70% of femoral and tibial osteolytic lesions showed evidence of graft incorporation following revision surgery.\(^1\) Griffin et al had a better success rate of 84% at a mean of 44 months.\(^1\)

Patient selection is critical for the success of IPE in the management of wear and osteolysis. The algorithm used in our institution is demonstrated in Figure 1. IPE and bone grafting can be considered in patients with well-positioned and well-fixed implants with no evidence of accelerated wear. In patients with aseptic loosening or mal-positioned components, or early and severe wear, a full revision is recommended. All osteolytic lesions should be bone grafted during the surgery.

**IPE for peri-prosthetic joint infection**

Peri-prosthetic infection is one of the most undesirable outcomes of a total joint arthroplasty procedure. The economic burden of an infected total joint arthroplasty is tremendous, with healthcare- and patient-related costs in the range of $50 000 to $116 000 per episode.\(^1\) Recent data from the Nationwide Inpatient Sample in the United States examined the cause of revision in over 60000 revision total knee arthroplasty procedures. Between 2005...
and 2006, 25.2% of revisions were because of infection, and 31.2% of those procedures included debridement, synovectomy, lavage and IPE as the mode of treatment. With the number of TKA procedures performed expected to rise exponentially, more attention and resources put towards diagnosing and managing peri-prosthetic infections is essential.

Two-stage re-implantation procedures are considered the ‘gold standard’ for treatment of deep peri-prosthetic infections, with success rates as high as 85%.22,23 Another option to consider is prosthetic retention following an irrigation and debridement and polyethylene exchange (IDPE).24 Exchanging the polyethylene allows greater access to the posterior aspect of the joint, permitting a more complete synovectomy and irrigation and debridement.25 Irrigation and debridement and polyethylene exchange is an attractive option in treating peri-prosthetic infections because it involves a single operation. This procedure may reduce the potential morbidity associated with a two-stage re-implantation procedure, such as loss of bone stock, soft tissue compromise, peri-operative fracture, pain and reduced range of motion.26,27 It may also reduce costs.

IDPE is a salvage procedure usually considered for early post-operative infections within one month after the index procedure, or acute haematogenous infections treated shortly after the onset of symptoms.25,28 The goal is to eradicate microbial contaminants before maturation of an extracellular polymeric biofilm.29 Typical bacterial pathogens identified in the early post-operative period include gram-positive cocci such as Staphylococcus aureus, coagulase-negative staphylococci such as Staphylococcus epidermidis and Staphylococcus haemolyticus, gram-negative bacilli, and the increasing number of methicillin-resistant Staph. aureus (MRSA) infections.25,30

Over the past two decades, several studies have attempted to determine the utility of IDPE in eradicating infection following a TKA. Mont et al demonstrated excellent efficacy in eradicating both early and late haematogenous infections in TKA.31 It should be noted, however, that half of these patients went on to two or more debridements with polyethylene exchanges before complete eradication at long-term follow-up. Their success rate in those undergoing only one IDPE was 41%. Segawa et al followed 81 infected TKA procedures, stratifying them based on the type of infection (positive intra-operative culture, superficial and deep early infections, late chronic infections and acute haematogenous infection).32 They suggested that successful treatment may depend on patient co-morbidities, as 57% of treatment failures occurred in patients with an immune-compromising disorder. Van Kleunen et al reviewed the role of IDPE in 13 patients with sub-fascial infections of a THA and TKA within 28 days of the index procedure.33 They compared these results with patients undergoing the same treatment procedure, but later than 28 days from their index procedure. At one-year follow-up, eight of the 13 patients (62%) retained their prosthesis if treated within 28 days, whereas only one of the five (20%) patients retained their prosthesis if treated after 28 days. Other studies have found that IDPE for infection later than 28 days from the index procedure has no impact on treatment success.29,30 A sub-group analysis by Choi et al determined that prosthesis retention was successful in 10 of 19 (53%) knees treated with IDPE versus zero of 13 knees treated with an IDPE.27

MRSA infection in total joint arthroplasty is associated with increased morbidity, mortality and inflated hospital costs.34 Particularly in TKA, MRSA infections are seemingly more resistant to traditional treatment.35 One study examined 19 cases of MRSA infections in TKA. After treatment with IDPE and four weeks of post-operative vancomycin, 16 failures occurred (84% failure rate).36 The authors of that study reported an overall success rate of 18% for IPDE.

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**Fig. 2** Algorithm for management of peri-prosthetic joint infection after total knee arthroplasty. IPE, isolated polyethylene exchange.
in acute peri-prosthetic MRSA infection of the knee. Parvizi et al followed 127 patients having either a THA or TKA infected with MRSA or methicillin-resistant *Staph. epidermidis* (MRSE), while 35 of those patients (11 knees) underwent an IDPE if their symptoms had onset within four weeks. There were 22 (63%) failed attempts at retaining the prosthesis, with half of the cultures growing MRSA and the other half MRSE. The influence of symptom duration within the 30-day window, which defines an acute infection on the outcome of IPDE, is controversial, and available evidence is limited. Not only is the definition of ‘acute’ nebulous, but it is also difficult to accurately define the onset of symptoms from patients’ history. Current evidence supports exchange arthroplasty if MRSA is discovered on aspiration of an acute peri-prosthetic knee infection or in cultures taken during urgent IPDE for acute infection.

There are several factors that may be responsible for treatment failure following IDPE for infected TKA. Segawa et al noted that the deep early infections failed in patients diagnosed with immune-compromising disorders, including diabetes mellitus, rheumatoid arthritis, renal failure, malignancy and corticosteroid use. Current evidence supports exchange arthroplasty if MRSA is discovered on aspiration of an acute peri-prosthetic knee infection or in cultures taken during urgent IPDE for acute infection.

IPE for stiffness and arthrofibrosis

Post-operative stiffness can be very frustrating and disappointing to patients. The incidence of post-operative stiffness is in the range of 8% to 60%, depending on the definition. In our institution, we define stiffness as diminished arc of motion less than 10° to 90° six weeks after the operation. The cause of post-operative stiffness is often multi-factorial. These include pre-operative range of motion, surgical technique, implant choice, soft tissue factors, post-operative physiotherapy and patient motivation.

Initial work-up should include investigations to rule out infection. Plain radiographs are useful to assess if the components are oversized or mal-positioned. CT scans can help to detect mal-rotation of the components. Early intervention starts at two weeks, when the patient fails to achieve 0° to 90°. There is no impact on the risk of treatment failure. However, other studies have demonstrated that virulent organisms predict poor infection-free survival following component retention, specifically MRSA, MRSE, methicillin-sensitive *Staph. aureus* or other coagulase-negative *Staphylococcus* species. The success of IDPE may also be time-dependent, as many studies suggest that a longer duration of symptoms following the index procedure before treatment may predict which patients will fail an IDPE.

Many of these studies are heterogeneous, with varying definitions of infection and treatment failure, non-standardised antibiotic regimes and differing time to follow-up. The literature clearly outlines the variable success rate when treating infected TKAs with an IDPE. Therefore, great care should be taken when selecting patients for IDPE as treatment for an infected TKA. Considerations include patient co-morbidities, onset of infectious symptoms since the index procedure, duration of symptoms and the infecting organism. The success of re-implantation procedures following a failed irrigation and debridement is not favourable, thus making patient selection of paramount importance. Based on current literature, we propose an algorithm as seen in Figure 2.
by component mal-alignment, failure to restore the mechanical axis, improper gap balancing, rupture of the PCL or MCL, and patellar tendon rupture or patellar fracture. These causes often require revision surgery with constrained implants and open reduction and internal fixation in the case of fracture. Late instability is most commonly caused by polyethylene wear, either alone or in combination with ligamentous instability. Based on these, we recommend an algorithm as seen in Figure 4.

Flexion instability in posterior-stabilised-TKA is a relatively uncommon but distinct problem that is often under-diagnosed. Patients may present with diffuse pain, especially when navigating stairs, a sense of instability without giving way, recurrent joint effusions and diffuse peri-articular tenderness. While most cases of KPI require revision surgery for successful outcomes, IPE may have a role in selected patients where component mal-alignment and mal-rotation is ruled out and a thicker and/or a semi-constrained insert can be used.15

IPE is performed for wear and osteolysis, early infection and arthrofibrosis. The results for addressing wear and osteolysis are moderate in the medium term, but should be avoided in cases of accelerated wear. In selected cases, debridement and IPE for early infection can result in low morbidity with high success rates in the short term. IPE for arthrofibrosis has poor results. IPE should be undertaken with caution and an institutional algorithm should be followed based on current literature.

Fig. 3 Algorithm for management of arthrofibrosis after total knee arthroplasty (TKA).

Fig. 4 Algorithm for management of instability after total knee arthroplasty. IPE, isolated polyethylene exchange; TKR, total knee arthroplasty.

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