Most problems encountered in complex revision total knee arthroplasty can be managed with the wide range of implant systems currently available. Modular metaphyseal sleeves, metallic augments and cones provide stability even with significant bone loss. Hinged designs substitute for significant ligamentous deficiencies. Catastrophic failure that precludes successful reconstruction can be encountered. The alternatives to arthroplasty in such drastic situations include knee arthrodesis, resection arthroplasty and amputation. The relative indications for the selection of these alternatives are recurrent deep infection, immunocompromised host, and extensive non-reconstructible bone or soft-tissue defects.

In revision total knee arthroplasty (TKA), the loss of soft tissue and bone are common and present a challenge for the surgeon to achieve a stable and functional knee. In most cases, difficult revision TKAs can be managed by increasing the constraint in the implant system. Designs with increasing constraint range from posterior stabilised, to constrained condylar, and to rotating hinge TKAs. A rotating hinge prosthesis is indicated in cases of incompetent or absent collateral ligaments, massive bone loss including collateral ligament origin or insertion, peri-articular fracture malunions or nonunions, and severe flexion gap imbalance.

Most massive hard- or soft-tissue defects can be managed with a rotating hinge design along with the use of modular metaphyseal sleeves or metallic augment or cones. However, extreme defects and instability can be present that preclude successful reconstruction with any available revision TKA system. In these situations, alternative treatment options should be considered.

The most common reason for selecting one of the alternatives to revision TKA is recurrent infection. Reported rates of infection vary. In the United States the infection rate following primary TKA ranges from 0.69% to 1.26%. Two-stage exchange protocol with interim use of an antibiotic cement spacer is the most preferred treatment. The re-infection rate after two-stage reimplantation has been reported to be as high as 28%. The duration of infection and host healing capacity have been reported to be the most important factors predicting the outcomes for patients with infected TKAs.

The physiological host healing capacity is an important factor in determining the potential for successful infection eradication. Host healing capacity has been previously classified by Cierny et al as: A, normal, uncompromised healing; B, local, systemic, or combined wound healing deficiencies; or C, significant compromising factors, high treatment morbidity, or poor prognosis with treatment worse than disability.

Local compromising host factors include vascular disease, multiple incisions or scarring, draining sinus or fistula, prior local radiation and lymphedema. Systemic compromising host factors are renal or liver failure, diabetes, cardiopulmonary disease, advanced age, metastatic disease, immune compromised states, alcoholism, smoking, and inadequate nutrition.

It is possible to improve the host healing capacity. A low total lymphocyte count or low total albumin indicates potential for wound healing problems. Oral or parenteral supplementation will elevate those parameters and improve the host healing response. Encouraging patients to make better choices, particularly cessation of alcohol and tobacco abuse, is important. However, these interventions have limitations and may not sufficiently optimise the host for predictably successful revision TKA.

When the surgeon determines that revision TKA is not the optimal treatment choice, treatment alternatives include arthrodesis, resection arthroplasty and amputation.

This review will focus on the indications, techniques, and outcome of these alternative treatments to address complex problems in revision TKA.
**Arthrodesis**

Knee arthrodesis does impose functional limitations. The patients must be made aware of the expected functional limitations pre-operatively. The surgeon must modify this treatment option based upon the clinical presentation and the patient’s expectations. Indications include recurrent deep infection, immunocompromised patient, extensor mechanism disruption, extensive, non-reconstructible loss of soft tissue, young physiological age, and high-demand patients. Contraindications include bilateral knee disease, ipsilateral hip or ankle disease, extensive segmental bone loss and contralateral lower extremity amputation.

The optimal position for arthrodesis of the knee has been proposed to be 15° of flexion, and 5° to 7° of valgus with neutral to slight external rotation of the limb. Slight knee flexion allows for foot clearance during gait. It also allows for a more comfortable position while sitting. Flexion at the knee increases the functional limb length discrepancy. Patients with bone loss of ≥ 3 cm should be fused in full extension. Hyperextension of the knee should be avoided. Factors that can affect the success rate of knee arthrodesis include bony contact, eradication of pre-existing infection, type of fixation used, and the type of previous implants. In addition to optimal bone contact and fixation stability, adequate blood supply and soft tissue coverage enhance the success rate.

Arthrodesis is the most successful when the infection is eradicated. Knutson et al. reported a fusion rate of 62% when infection was controlled pre-operatively compared with a fusion rate of only 19% when arthrodesis was performed with an active infection. A history of infection also delays the time to clinical union after knee arthrodesis. The mean time to successful arthrodesis was 11.3 weeks in aseptic cases compared with a mean of 20.8 weeks in those cases with residual infection. The success of knee arthrodesis has also been demonstrated to depend upon the type of knee arthroplasty implants used in previous surgeries. The union rate for patients with failed unicompartmental TKA is higher than in those patients with a failed hinged prosthesis (averages of 86% versus 51%).

The type of fixation used to achieve the arthrodesis is also important. Options include 1) an intramedullary (IM) nail; 2) external fixation with a uniplanar, biplanar, or circular fixator, or 3) compression plates.

Most surgeons prefer the use of an IM nail for the index surgery, and multiple studies have reported fusion rates of 100% (Fig. 1). However, an IM nail may not be suitable in all cases. For instance, an external fixator is the construct of choice if there is active or recurrent infection as there is no residual hardware (Fig. 2). In fact, the reported rate of infection after arthrodesis is lower with the use of an external fixator compared with an IM nail (4.9% versus 8.3%). The biggest disadvantage to using an external fixator for knee arthrodesis is a decreased union rate when compared with IM nails (67% versus 95%). Biplanar external fixators have been reported to result in higher union rates than using uniplanar fixators (66% versus 33%). Plate fixation is best reserved for failed arthrodesis with other methods of fixation (Fig. 3). Dual plating achieves more rigid fixation than using a single plate. The authors recommend the use of an IM nail for knee arthrodesis in most cases.

Regardless of the technique, rigid fixation with compression is the principle prerequisites for successful arthrodesis. In cases with less than 50% apposition of viable cancellous bone, bone graft should be used. Most authors recommend autologous iliac crest bone graft. In some cases, the residual patellar bone or allograft bone may also be used. A successful knee arthrodesis provides the patient with a durable, stable, and painless knee. Patients often complain of difficulty with stairs and discomfort in sitting. In addition, degeneration of the adjacent joints and the spine is
expected to contribute to the long-term morbidity and functional limitations.

**Resection arthroplasty**

Resection arthroplasty is rarely optimal for the patient. For the low demand patient, resection arthroplasty can be well-tolerated and functional. Advantages of resection arthroplasty over arthrodesis include: 1) it allows the patient to sit more comfortably; 2) it involves no residual hardware in the setting of infection; and 3) it generally requires only one surgical procedure. The primary complication with resection arthroplasty is knee instability. During the surgery, all implant components and residual cement must be removed (Fig. 4). The bone ends should be contoured. Post-operative support should be provided with a controlled arc of motion knee–ankle–foot orthosis (KAFO). Immobilisation is initially in extension. As comfort is achieved, the controlled arc is changed to a range of 0° to 90°, and flexion movement is encouraged.

Falahee et al. reported that 15 of 26 patients (57%) could ambulate without assistance after resection arthroplasty. However, six of the 26 patients required conversion to arthrodesis due to disabling instability. Due to the functional limitations of resection arthroplasty, it is usually reserved for patients with severe pre-operative disability, including sedentary patients, and patient with polyarticular disease. Resection arthroplasty may also be used as a staging procedure to arthrodesis or amputation if not tolerated by the patient, or with residual chronic infection.

**Amputation**

Patients who are not amenable to arthrodesis or resection arthroplasty may be best treated with amputation. These patients often have had multiple failed revision TKAs or arthrodesis attempts. Other patients may have recurrent or life threatening infections. Some patients may have low probability of successful arthrodesis due to the loss of bone or infection. Lastly, some may not tolerate resection arthroplasty and the use of bracing. Medical comorbidities may preclude the patient from undergoing multiple procedures, thus making amputation the most efficacious and safe alternative.

The amputation should be performed at the lowest level that will eradicate infection but provide the best potential for prosthetic fitting and function. Use of an above knee prosthesis demands a high-energy output and is, therefore difficult for the elderly and the obese patients. Sierra et al. reported the prevalence of above-the-knee amputation (AKA) for complications related to TKA to be 0.14% in a large series of over 18,000 primary TKAs. Nine of twenty-five patients (36%) were fitted with a prosthesis, and only five (20%) were able to walk at final follow-up. In another study of 23 patients with AKA, only seven (30%) were regular daily walkers. In general, patient function after AKA is poor, and both patients and surgeons should be aware of this prior to pursuing this treatment option.

**Conclusion**

Management of patients with catastrophic failure of a TKA is a challenging situation for the orthopaedic surgeon. The most common reason for selecting an alternative to revision TKA is persistent infection. The best treatment option must be individualised on a case-by-case basis. In most cases, limb salvage with resection arthroplasty or knee arthrodesis is preferable to amputation. In the younger or high-demand patients, arthrodesis is often the treatment of choice. In selected older and low-demand patients, acceptable functional capacity and pain relief may be achieved using resection arthroplasty. Amputation is typically reserved for the patients with life threatening sepsis or who have failed other treatment options.
No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. This paper is based on a study that was presented at the Winter 2011 Current Concepts in Joint Replacement meeting in Orlando, Florida, 7th – 10th December.

References