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ORIGINAL STUDY

Total knee arthroplasty in patients with prior adjacent multi-organism osteomyelitis

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Joint degeneration may make a total knee replacement a requirement for pain relief and function, however the presence of adjacent osteomyelitis makes management extremely challenging. We describe a series of four patients with a mean age of 50 with multi-organism osteomyelitis who underwent single-stage total knee replacements at an average of 63 months following eradication. Three patients did well but had complications associated with poor skin and soft tissues, and abnormal bone anatomy. One patient developed an infection and following a re-revision had an arthrodesis. The final mean Knee Society Score and Oxford Knee Score was 62 (54-66) and 34 (29-38) respectively. We have highlighted that these are a difficult cohort of patients to manage and their care is optimised through a multi-disciplinary approach by a high volume surgeon.

Keywords : Osteomyelitis ; Multi-organism ; Knee ; Arthroplasty ; Arthrodesis.

INTRODUCTION

Osteomyelitis can cause significant bone destruction and disruption to the soft tissues resulting in pain, systemic malaise and functional deficit. These patients are at risk from developing degenerative changes in their joints due to septic arthritis, disruption to joint biomechanics or secondary to previous trauma associated with the original osteomyelitis *(1,8)*.

Total knee replacement is generally a successful procedure with a good outcome, however patients with a history of osteomyelitis are at a higher risk of developing an infection in their joint replacement *(3)*. Infections in joint replacements cause significant morbidity and mortality leading to increased cost for both the patient and the health service *(6,12)*.

With the emergence of more resistant organisms and polymicrobial infections *(14)*, osteomyelitis remains a difficult problem to manage *(5)*. Additionally, patients have greater expectations and seek to restore function and relieve osteoarthritic pain with joint replacement surgery, as soon as there is clinical evidence the infection has resolved. Historical studies *(4,13)* tend to perform joint replacements decades after previous active osteomyelitis, but today patients do not expect to waiting for that long.

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We report the experience of a single high volume revision knee surgeon managing adjacent multi-organism osteomyelitis and subsequent single-stage primary knee arthroplasty in four relatively young patients. These patients were reviewed to determine the results with single-stage surgery and the use of uncemented implants, and look at the complication profile.

METHODS

Four consecutive patients were identified who had either ipsilateral femoral or tibial chronic osteomyelitis treated prior to undergoing total knee arthroplasty. Surgery to eradicate the osteomyelitis involved a Lautenbach compartmental debridement and where necessary healing by secondary intention. The decision to proceed to a total knee arthroplasty was based on history, clinical examination and radiological findings of advanced osteoarthritic change.

All patients underwent clinical, radiological and haematological assessment to ensure the infection was not active. Clinical assessment included history for systemic malaise, routine observations and clinical examination of the joint and the surrounding areas. Active infection was suggested by the presence of erythema, swelling, warmth and reduced movements. Radiological investigations included radiographs, and a triple-phase bone scan was performed if any of the other parameters suggested an active infection. Haematological assessment included White Blood Cell (WBC) count and differential including neutrophils, C- reactive protein (CRP) and Erythrocyte Sedimentation Rate (ESR). Where there was a suspicion, a bone biopsy was performed to exclude an infection. We did not perform any Magnetic Resonance Imaging (MRI) scans.

Patients were managed by a multi-disciplinary team with individualised antibiotic protocol based on recent sensitivities, drug allergies and intraoperative findings. Intra-operatively, in accordance with the local Health Board policies, all routine infection control precautions for joint arthroplasty were taken including laminar flow.

A midline skin incision and a medial para-patellar arthrotomy was performed as standard but when necessary the approach was tailored to account for previous trauma, incisions and skin grafting. In addition to a complete synovectomy, thorough surgical, mechanical and chemical debridement was performed in accordance with the senior author's protocol for infected single stage knee revision arthroplasty *(15)*. The choice of knee replacement was based on age and bone quality as per the senior author's routine practice. Uncemented knee implants (Zimmer NexGen/TMT) were used in two patients, while in the other two patients, Pallacos G antibiotic loaded cement with 0.5mg/bag gentamicin was used to secure fixation of Sigma PFC implants. No patient was found to have clinical evidence of active infection intra-operatively, and multiple biopsies sent for microbiological analyses failed to grow any organisms.

Extra medullary tibial alignment was performed in all cases. Computer assisted distal femoral alignment was used in the patient with previous femoral osteomyelitis to avoid potential 'contamination' of the sterile field.

Demographic, clinical, microbiological and radiological outcomes were analysed. The Knee Society Score (KSS) and the Oxford Knee Score (OKS) were also measured at final follow-up.

RESULTS

The results for the four cases are summarised in Table 1. The site of osteomyelitis was in the ipsilateral proximal tibia in three cases and distal femur in one case. All cases had multi-organism osteomyelitis as outlined in Table 1, but Staphylococcus aureus and Pseudomonas were present in all four cases. The mean duration from a time of osteomyelitis eradication to total knee replacement was 63 months (range 12-122 months).

The mean age of the patients was 50 years (range 40-66 years) at the time of arthroplasty. Cases 1 and 3 underwent uncemented arthroplasties, whereas Cases 2 and 4 had cemented arthroplasties. The series had a mean follow up of 63 months (range 24-128 months). All patients were initially followed up at 6 weeks, 3 months and a year with no recurrent signs of infection.

Table 1. — Details of four cases including osteomyelitis, total knee replacement and outcome

Case	OM Site and relevant history	Organisms grown from microbiological specimens from OM	Interval between osteomyelitis eradication and TKR	Age at TKR	Final follow-up	Preoperative ROM, ROM at final follow-up	Post-operative complications	Outcome at final follow-up	Knee scores (KSS= Knee Society Score, OKS= Oxford Knee Score) at final follow-up
1	Right tibia and ankle OM secondary to trauma. Skin ulceration and underlying necrotic bone in tibia debrided 12 months prior to TKR	Staphylococcus aureus Coagulase -ve Staph Pseudomonas Coliform species Coryneforms	84 months	51	71 months	20-70 to 0-70	Prolonged wound healing requiring VAC dressing for 2 months	Independently mobile	KSS 64, OKS 38
2	Right tibia Immunocompromised with diabetes and on long-term steroids for rheumatological condition.	Staphylococcus aureus Non-haemolytic Strep Coliform species Coryneforms Mixed anaerobes Pseudomonas	122 months	66	24 months	10-60 to 0-80	MCL rupture at 4 weeks managed non-operatively	Mobilising with one stick	KSS 66, OKS 34
3	Left tibia and fibula with previous proximal tibia pathological fracture 18 months prior to TKR	Staphylococcus aureus Group G Strep Mixed anaerobes Coliform species Pseudomonas	12 months	40	128 months	20-60 to 10-70	116 months post-operatively, pathological tibia and fibula re-fracture requiring external fixation followed by sarmiento casting	Independently mobile	KSS 63, OKS 36
4	Left femur OM secondary to trauma. Skin graft over the medial aspect of proximal tibia	Staphylococcus aureus Coagulase -ve Staph Alpha haemolytic Strep Group B Strep Pseudomonas aeruginosa Coryneforms	34 months	42	72 months	0-30 to fusion	MRSA infection of TKR requiring revision at 26 months, MRSA infection of revision at 59 months requiring two-stage fusion	Mobilising with 2 elbow crutches, off antibiotics, taking PRN analgesia only	KSS 54, OKS 29

OM= Osteomyelitis, TKR= Total Knee Replacement, ROM= Range of Movement, MCL= Medial Collateral Ligament, MRSA= Methicillin Resistant Staphylococcus Aureus

The mean KSS and OKS were 62 (54-66) and 34 (29-38) respectively. Three out of four patients subjectively had "good" or "excellent" clinical and radiological outcomes at follow up. Radiographs at last follow-up revealed a well-aligned knee arthroplasty implants with no evidence

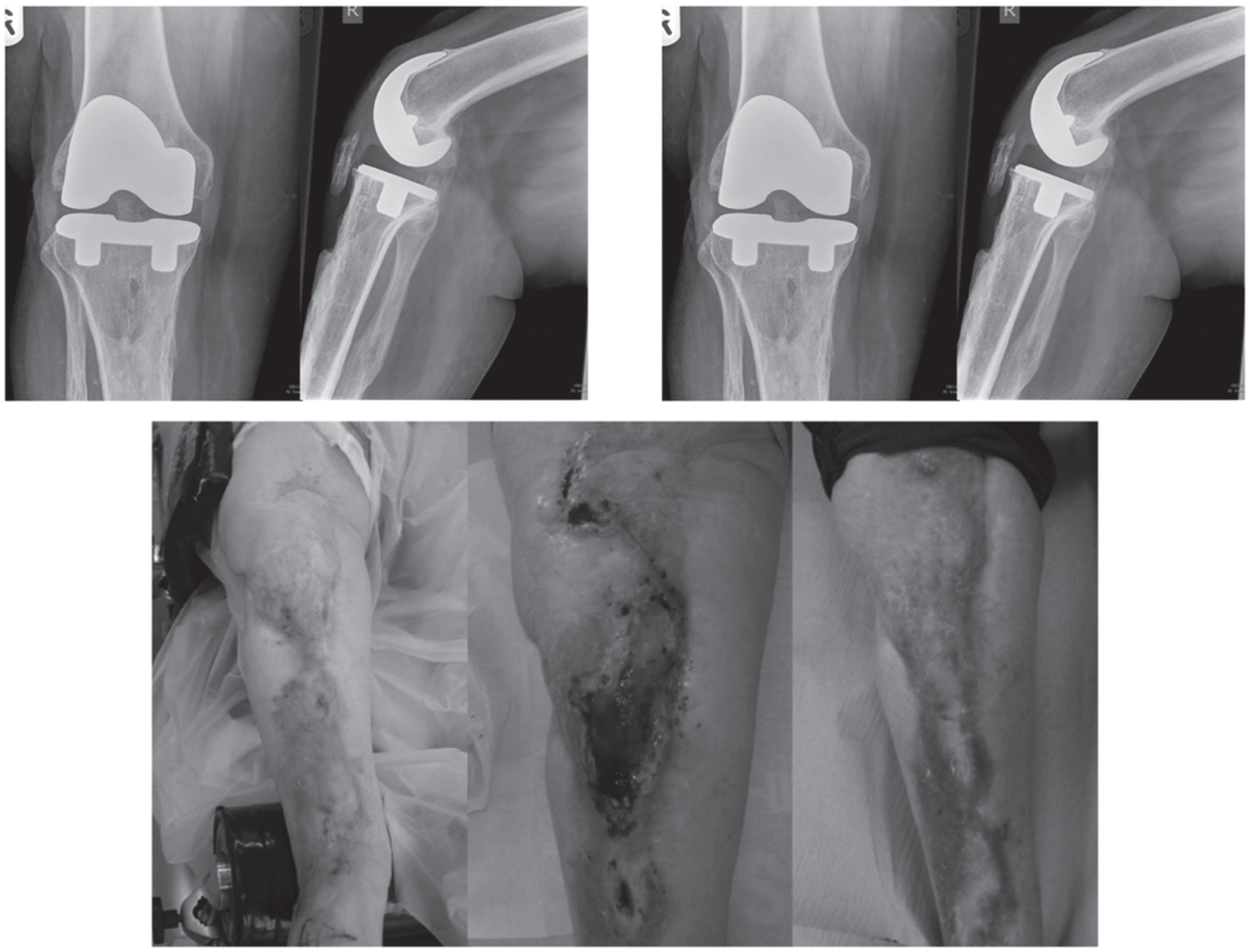


Fig. 1. — Pre-operative (a) and final follow-up post-operative (b) antero-posterior and lateral radiographs for Case 1. Clinical photograph of Case 1 preoperatively (c), postoperatively with wound breakdown (d), and after wound closure following application of VAC dressing (e).

of loosening, infection or heterotopic ossification (Figures 1-3 a-b). The average range of motion increased in three cases after the primary knee replacement from a mean of 17-63 degrees to 3-73 degrees. These three patients clinically remained well with no evidence of recurrence of infection. They all sustained early or late complications due to the effects of osteomyelitis and associated skin, soft tissue and bone changes; Case 1 had delayed wound healing requiring a VAC pump (Figure 1 c-e), Case 2 sustained a medial collateral ligament (MCL) rupture that was managed non-operatively, and Case 3 sustained a delayed tibia re-fracture due to abnormal bone anatomy at the site of the previous osteomyelitis, almost 10 years following the knee replacement and was managed successfully with an external fixator (Figure 3 c-d). All three complications had resolved by final follow-up with no lasting consequence on the knee replacement. At final follow-up two patients were mobilising unaided, and one patient was mobilising with a stick.

Unfortunately one patient (Case 4), who had previous distal femoral osteomyelitis, underwent subsequent multiple stage revision surgery for Methicillin Resistant Staphylococcus Aureus (MRSA) infection. The patient had osteomyelitis secondary to trauma, and had associated

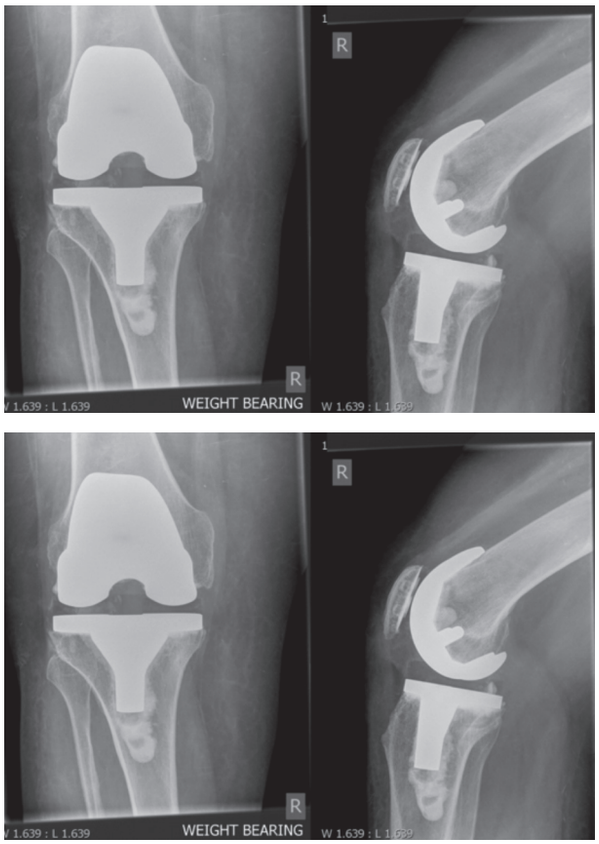
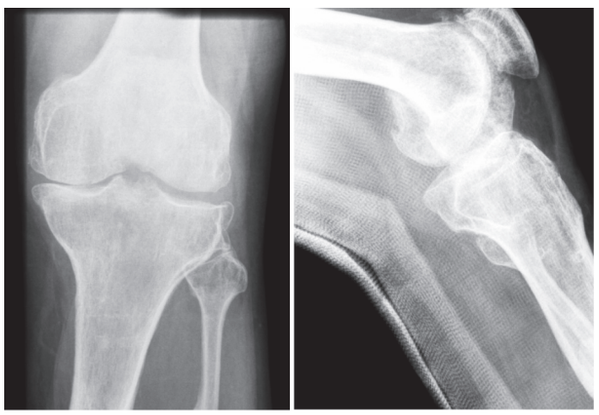


Fig. 2. — Pre-operative (a) and final follow-up post-operative (b) antero-posterior and lateral radiographs for Case 2

compromised soft tissues with a skin graft over the proximal tibia. MRSA had not previously been isolated from cultures prior to knee arthroplasty. The patient underwent a single-stage revision at 26 months, and a two-stage fusion at 59 months, again for MRSA infection (Figure 4). n initial medical



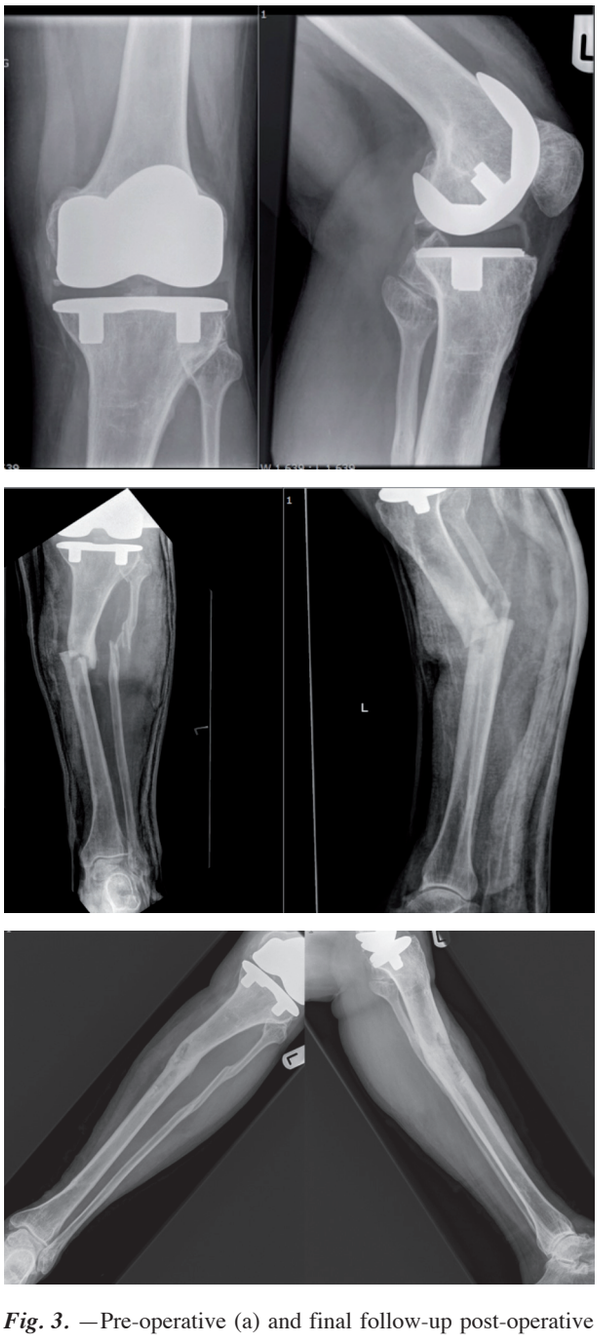


Fig. 3. —Pre-operative (a) and final follow-up post-operative (b) antero-posterior and lateral radiographs for Case 3. Antero-posterior and lateral radiographs for Case 3 following fracture of the tibia and fibula following fracture (c), and at last follow-up (d) having been managed with an external fixator

record query yielded a list of 65 potential patients with MS. After a thorough review, 21 patients were excluded due to a lack of clear diagnosis of

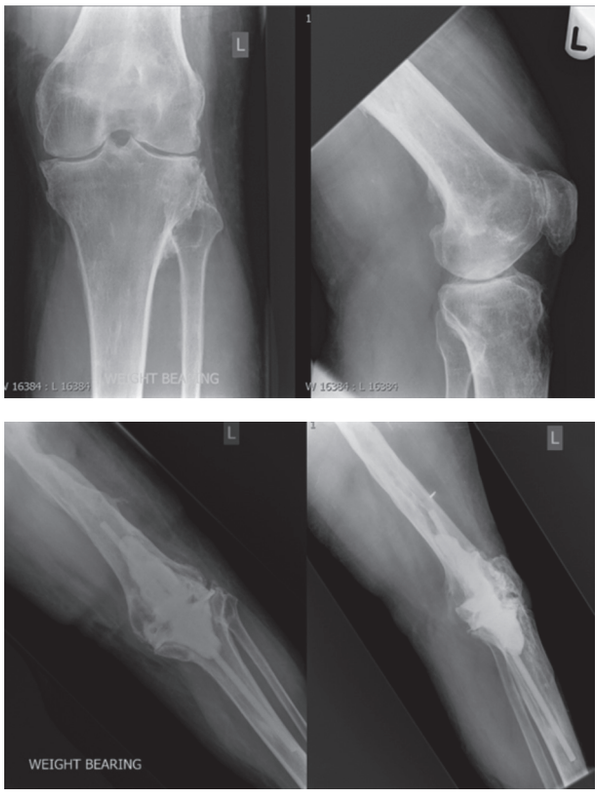


Fig. 4. — Pre-operative (a) and final follow-up post-operative (b) antero-posterior and lateral radiographs for Case 4

MS. This left us with 44 (23 female and 21 male) patients to include in our review.

Sixteen patients were diagnosed with a upper limb disorder. There were three patients with a diagnosis of a hand deformity/condition other than PS. One patient was diagnosed with snydactyly, one with symbrachydactyly, and one with an absent digit on the left and syndactyly on the right hand. No surgery was needed for any of these patients.

Nine cases of PS were identified based on absence of the pectoralis tendon in the axillary fold. One patient had no hand abnormality, three had syndactyly, three had symbrachydactyly, and two patients had a dual diagnosis of syndactyly and symbrachydactyly. Five patients were effected on the right side, and four on the left. Six patients with PS had surgery for syndactyly release. There was no revision needed for these patients. Three syndactyly patients had also clubfoot deformity. One of those three patients had surgery for his foot deformity, other 2 patients were treated with casting for their foot deformity.

Two patients had multiple upper extremity contractures. One patient had multiple surgeries including bilateral humerus supracondylar osteotomy, carpal wedge osteotomy, and soft tissue procedure.

Rarely common diagnose included transverse deficiency and shoulder deformity. One patient had bilateral upper limb deficiency, and one had bilateral shoulder deformity without any hand disorder.

Four patients had syndromes concomitant with MS. These syndromes included Arthrogryposis, Pullman syndrome with two patients, Attention Deficit Hyperactive Disorder (ADHD).

DISCUSSION

A total knee replacement following adjacent bone osteomyelitis is challenging, not only in view of the risk of recurrence of infection, but also due to increased the risk of complications from associated skin, soft tissue and bone changes. Although two-stage knee replacements after osteomyelitis affecting the knee joint have been described *(9,10)*, all patients in our series underwent a single-stage procedure. This procedure was carried out using the strict protocol followed for single-stage infected knee revisions *(2)*.

We reviewed the literature to identify previous reports of knee arthroplasty in patients with a history of adjacent bone osteomyelitis. The study by Jerry et al (1988) *(4)* is the largest study of total knee replacements with a history of prior infection. The study included 20 patients with prior infection of both the bone and joint. They reported good results with only 15% recurrence of deep infection. The study was limited by diagnosing infection only by patient history and there may have been an element of recall bias after a mean of 18 years (range 1-65 years). Another explanation for the good results could be the less virulent organisms present at the time and the historical nature of any previous infections. The authors suggest that antibiotic-impregnated cement should prophylactically be used.

The study by Lee et al (2002) *(7)* included four patients with prior distal femoral and/or proximal tibial osteomyelitis, and two patients with prior bone and joint sepsis at the knee. Again there was a long average interval from the original diagnosis to total knee replacement of 23 year (range 1-66 years), almost five times longer than in our series. Haematological, radiological and microbiological investigations were performed to exclude any active infection. The authors do not state how many patients had positive results and were excluded from the study. One patient underwent a two stage procedure, again with no explanation. All six patients included in the study were doing well at final follow-up.

The study by Nazarian et al (2003) *(10)* reports three patients with osteomyelitis who underwent two-stage total knee replacement at an average of 3.1 months after the first stage. The Knee Society scores improved from 46 to 89, with an average range of motion from 3-105 degrees. None of the patients had a recurrence of infection at an average 4.5 years follow-up.

With a history of osteomyelitis, there is a concern that a total knee arthroplasty may activate dormant microorganisms. Although there have been reports of implants without antibiotic loaded cement used in cases with a history of osteomyelitis *(11)*, most authors suggest the use of antibiotic impregnated cement *(4,7)*. Cases 1 and 3 in our series had uncemented knee implants and had no evidence of recurrence of infection at final follow-up. As with a non-complex arthroplasty, implant fixation should be chosen on the merits of the individual patient and bone quality as is the case with uncemented or cemented revision knee replacement following prosthetic joint infection.

Arthrodesis is an appropriate option for patients where infection eradication was not successful as in Case 4 of our series with recurrence of MRSA infection. There are however risks of non-union, malunion or recurrence of infection, as well as functional limitations for the patient. We believe that this procedure was performed at the right stage for this patient. Amputation is successful in eradicating infection but is associated with significant functional deficit *(13)*.

CONCLUSIONS

The high incidence of infection in patients with a history of osteomyelitis who undergo knee arthroplasty could be related to poor blood supply, soft tissue scarring, increased intraoperative time or residual infection. The high incidence of other complications is likely to be due to associated skin, soft tissue and bone abnormalities. We recommend haematological, radiological and microbiological assessment to exclude active infection before proceeding with total knee replacement, as well as a multi-disciplinary approach to their management. Despite the increased risk, with careful preoperative management of recent adjacent osteomyelitis and thorough debridement, total knee arthroplasty can be achieved as a single-stage. We advocate a single-stage procedure using strict debridement protocols only in a high volume centre.

Conflicts of Interest: No conflicts declared..

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