Periprosthetic joint infection in relation to elbow arthroplasty

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Abstract

Periprosthetic joint infection (PJI) has huge functional implications for the patient and financial implications for any healthcare system. The scope of any surgery in these cases is limited by the bone stock, the soft tissue envelope and the often-tenuous neurovascular structures. For that reason, both preventing PJI within the elbow and managing it correctly are the keys to getting it right first time. With this in mind, we provide an insight into the prevention of PJI in the elbow and also an overview of how to manage PJI with specific reference to the unique characteristics of the elbow.

Keywords elbow replacement; infection; periprosthetic joint infection; post-traumatic arthroplasty; two-stage revision

Introduction

Periprosthetic joint infection (PJI) has adverse and devastating effects on the function of the involved limb. Since the elbow's primary role is to position the hand in space, an infected elbow replacement disturbs all functions of the hand and its interaction with the environment. There have been a number of published series and reviews looking specifically at infection rates following total elbow replacement (TER). Over the last three decades the deep infection rate in TER has been reported to be between 3% and 11%.[1–5] Infection reported as the reason for revision within the UK National Joint Registry (NJR) currently is 1.13% for elbow arthroplasty.[6,7] Some authors have reported that infection rates might be reducing with time.[4,8,9] However, a recent large case series found the contrary.[3] Though there is no doubt that surgical techniques have changed to try and minimise infection and loosening, it may well be that the increased use of disease-modifying anti-rheumatic drugs (DMARDs) and the increased prevalence of TER for trauma and post-traumatic indications are to blame for the lack of overall effect of these measures.

The complex decision-making that goes into each and every TER, whether a primary or revision, is outside of the remit of this article. When faced with an obviously infected TER, the surgeon needs to establish whether they have the knowledge, skills and resources to deal with the problem. Patients with an infected TER tend not to present systemically unwell and, therefore, can be transferred to an outpatient setting within a regional hub that specializes in dealing with higher volumes of such cases. This article will provide an overview of how to approach infection residing in the tissues prior to a primary TER, and PJI associated with elbow replacements. The techniques to ensure adequate debridement, appropriate sampling, antibiotic administration and definitive reconstruction are discussed, with special reference to the management of bone loss in the presence of an infected TER.

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Clinical assessment and investigations

The patient's history and examination, combined with a plain radiograph, are often enough to determine whether an elbow is infected, whether or not there is a TER in-situ. Other articles in this issue have discuss the salient features of the history and examination that are applicable to any PJI, and the elbow is no different. In terms of investigations, a myriad of blood tests and imaging studies are available, which have also been discussed elsewhere. In this article, we will rather consider a number of distinct presentations, which should help the reader to identify and treat the most commonly encountered and relevant scenarios in clinical practice thus:

1. A native elbow requiring TER, in which infection is either present or is a possibility (osteomyelitis, previous fracture fixations, radial head replacement, previous rheumatoid surgery).
2. The 'unhappy' TER, which may or may not be infected.
3. The obviously infected TER.

The native elbow: preventing PJI

Infection within a native elbow is rare. When it presents in an elbow as septic arthritis, it is frequently an acute presentation with limited or no cartilage damage, and can be treated quite successfully (eradicated) with a joint washout, debridement and administration of antibiotics. In contrast, there are two groups of patients who require special consideration before implanting an elbow replacement. The first group is those patients who present with a destructive arthritis with progressive radiographic changes that behave like an aggressive inflammatory arthropathy. Figure 1 shows the radiographs of a patient who had undergone an excision of a rheumatoid nodule and olecranon bursa. There were some wound issues postoperatively and the elbow joint became more painful over the subsequent few months, developing audible crepitus and instability. A simple radiograph 4 months later reveals the issue and, clinically, all the parameters were consistent with infection. At surgery there was copious pus in the joint and, not surprisingly, the microbiology was positive in all seven samples that were taken during surgery. An antibiotic spacer was placed to provide stability and to elute antibiotics within the joint space. These individuals may occasionally present with some warmth or redness around the elbow with pain throughout their limited range of movement.

The second group of patients have developed post-traumatic arthritis following surgical procedures, often following trauma. There may well be history of wound issues or 'superficial' infection, which have now long since resolved. Figure 2 shows a radiograph of an elbow that had undergone fixation of a

Figure 1 Radiographs taken 4 months apart revealing joint destruction affecting both the ulnohumeral and radiocapitellar joint highly suspicious for infection.

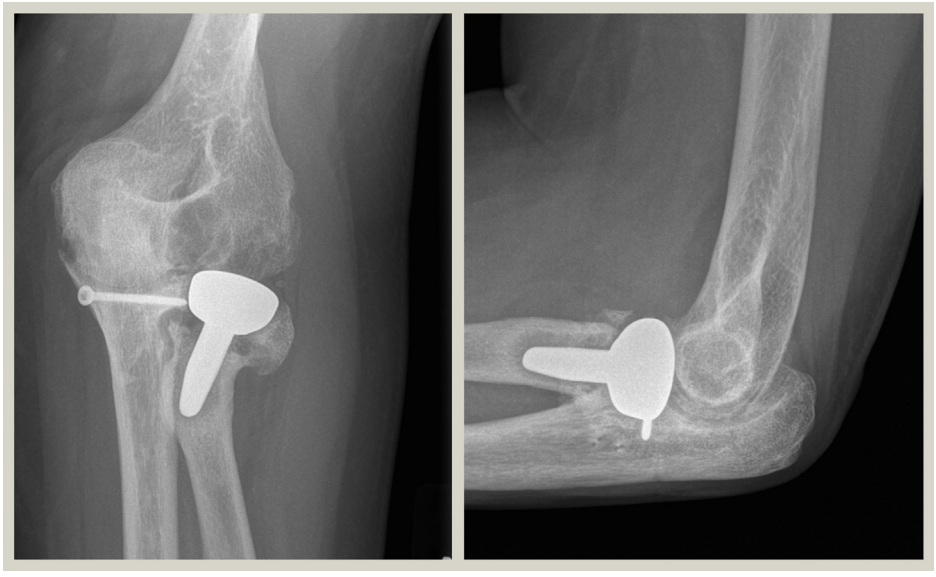

Figure 2 Radiographs 5 years following previous surgeries for a Monteggia fracture dislocation of the elbow showing a loose radial head replacement in-situ and central destruction of the ulnohumeral articulation.

Monteggia-variant injury 5 years previously. There were some wound issues over the ulna in the early postoperative period, so the locking plate was removed. Since then there were no wound issues, just progressive elbow pain. A decision was made to perform a two-stage procedure, actually hoping to preserve the joint. Through an elbow replacement incision, the radial head prosthesis was removed and the joint was debrided, released and deep tissue sampling was undertaken. It was not deemed to require a cement spacer at the time of surgery. All the samples were negative including extended culture results and eventually, despite further rehabilitation, the patient required TER, which could then be confidently carried out as a single-stage procedure (Figure 3).

In the above cases, the presence of deep infection should be a major concern and rushing into a TER and missing a pre-existing deep infection can lead to disastrous consequences. Our preferred treatment in patients who require a TER, but may harbour a deep infection, is a two-stage primary elbow replacement. Using a TER approach, we remove any implants, excise any dead or infected tissue and send five high-quality deep tissue samples. We place a

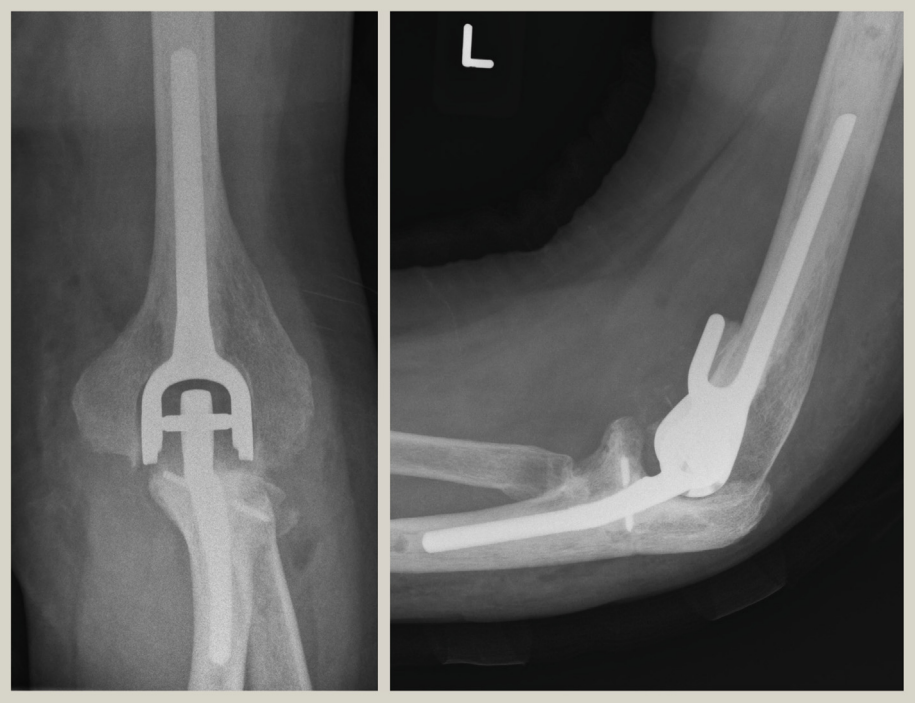

Figure 3 Radiographs following a total elbow replacement on the patient from Figure 2, who underwent this procedure following negative open biopsies.

temporary, high-dose antibiotic spacer and deliver systemic antibiotics based upon the culture results. In the setting of positive microbiology, we treat the patient with a 6-week course of appropriate antibiotics (intravenous or oral), followed by at least a 4-week antibiotic-free window prior to implanting a TER. If the microbiology samples are negative, then all antibiotics are stopped in the early postoperative period and a TER is carried out dependent upon adequate condition of the soft tissue envelope. We have never regretted performing these cases as two-stage procedures and patients often understand the gravity of the situation that would exist if an infection were missed.

The 'unhappy' total elbow replacement

This refers to the situation where a patient may complain of pain, slight redness or heat around the elbow with a TER in-situ. The wound is often found to be pristine and the radiographs look reasonable, with no progressive loosening of the implant-cement or cement–bone interfaces. The first thing to understand is that an untreated deep infection within a TER will eventually declare itself and is highly unlikely to be life-threatening. For that reason, in a patient that is not a good surgical candidate or does not want to consider multiple investigations and further surgery, it is an acceptable form of management to watch-and-wait. In this situation, the patient must be told that there may well be a deep infection and of the warning signs they should look out for, and seek urgent medical attention if encountered.

Some patients will not be happy with a watch-and-wait approach and will want to know definitively whether there is an infection or not. In these cases, the blood tests and advanced imaging modalities provide some evidence. However, since microbiology is diagnostic, deep tissue sampling is the only way in which one can be sure whether a symptomatic TER is infected

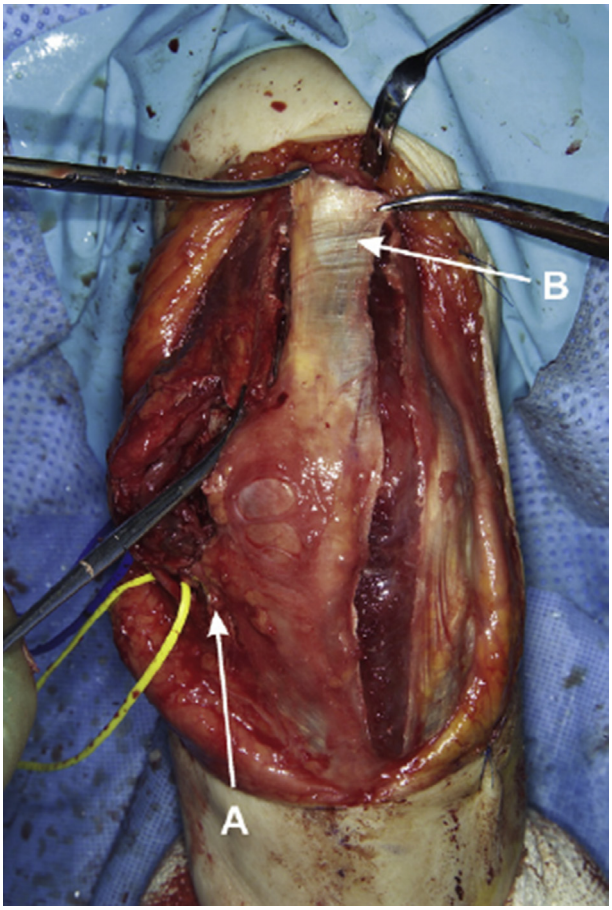

Figure 4 Intraoperative photograph showing the classical triceps tongue approach with a yellow sloop (A) around the ulnar nerve and the surgical clip (B) on the divided central band of the triceps for repair later.

or not. There are a number of ways to sample a TER; a simple aspiration, open deep sampling or as part of a formal first-stage revision elbow replacement. With regards to aspiration, if infection is more likely than not, an aspiration may confirm suspicions and identify the bacterium responsible. This is useful if a single stage revision is considered to be appropriate. That said, a negative aspiration does not rule out infection and since we see limited indications for single-stage revision of the elbow, aspiration is rarely utilised in our hands.

Our preferred techniques are either open biopsy or proceeding directly with a first-stage revision including tissue sampling. The technique used depends on whether the implant is well fixed or not[1]. In the presence of a well-fixed implant, a first-stage procedure to remove the prosthesis and all the cement is a huge undertaking and often involves the creation of bony windows to access the prosthesis without fracturing the humerus or ulna. For this reason, if the diagnosis of infection is still in doubt, open biopsies are the more appropriate investigation. This can be carried out through a small posterior approach to access the implant and implant–bone interface, before taking five deep tissue samples prior to antibiotic administration. If the prosthesis is radiologically and clinically loose, it more than likely requires revision anyway. In these cases, it makes more sense to take the open biopsies at the same sitting as the first-stage revision with removal of the prosthesis and all the remaining cement followed by the insertion of an antibiotic cement spacer.

The obviously infected total elbow replacement

When a TER is confirmed to be infected, or obviously infected from the outset (presence of communicating sinus or discharging pus) surgery needs to be considered. If the infection follows soon after implantation surgery or appears to represent acute haematogenous spread in a previously perfect, well-fixed TER then debridement, antibiotics and implant retention (DAIR) can be considered.[10] The prosthesis should be unlinked and separated, all modular components removed prior to extensive debridement from superficial to deep (with multiple samples for microbiology) including a thorough lavage,[11] prior to reimplantation of new modular components and closure. Within the first 2–3 weeks after implantation DAIR should definitely be considered. A successful DAIR relies on good soft tissue cover and the presence of an infection that is susceptible to antibiotics which themselves have excellent bone and joint penetration. Still, the DAIR technique has only been shown to have a success rate of between 50% and 80%.[12,13] Beyond 6 weeks DAIR is highly unlikely to be successful due to the formation of a biofilm on the implant, which prevents the action of antibiotics.

In a chronically infected TER, the gold standard treatment remains two-stage revision with around an 80% success rate.[14] There is insufficient evidence in the literature to recommend single-stage revision, except in particular circumstances related to the frailty of the patient and their comorbidities.[8] Other than in these cases, the indications for single-stage revision surgery are probably very limited.[15]

Two-stage revision elbow replacement

Revision procedures are challenging and must take into consideration the management of the soft tissue envelope, any bone loss and protection and preservation of the neurovascular structures (especially the ulnar nerve). A successful outcome is

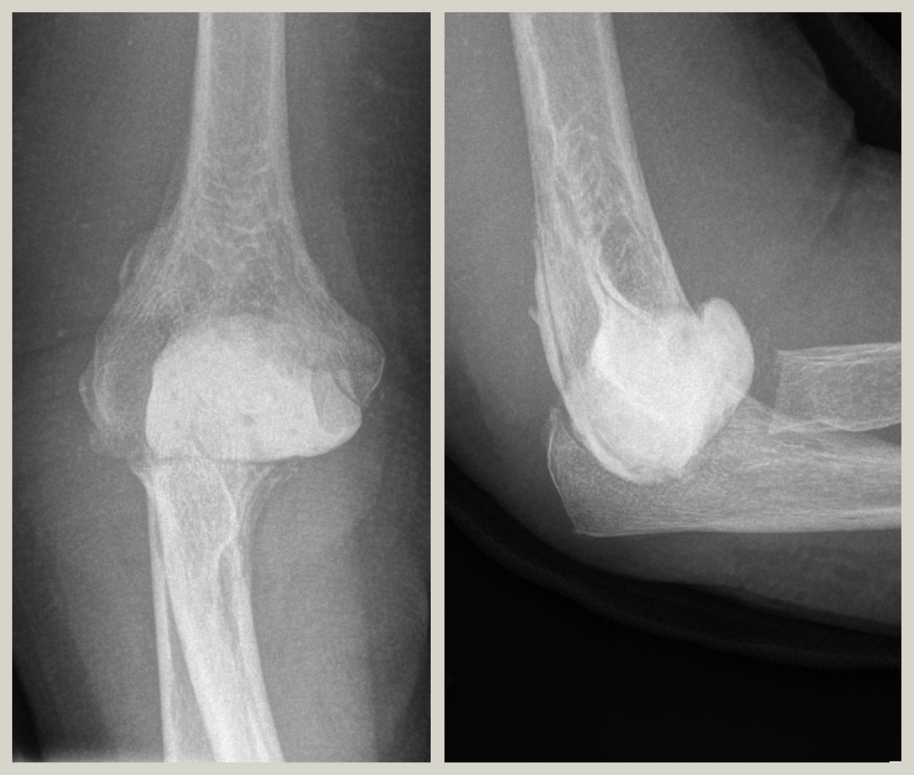

Figure 5 Radiographs showing a dynamic cement spacer in-situ following the first stage of the patient in Figure 1.

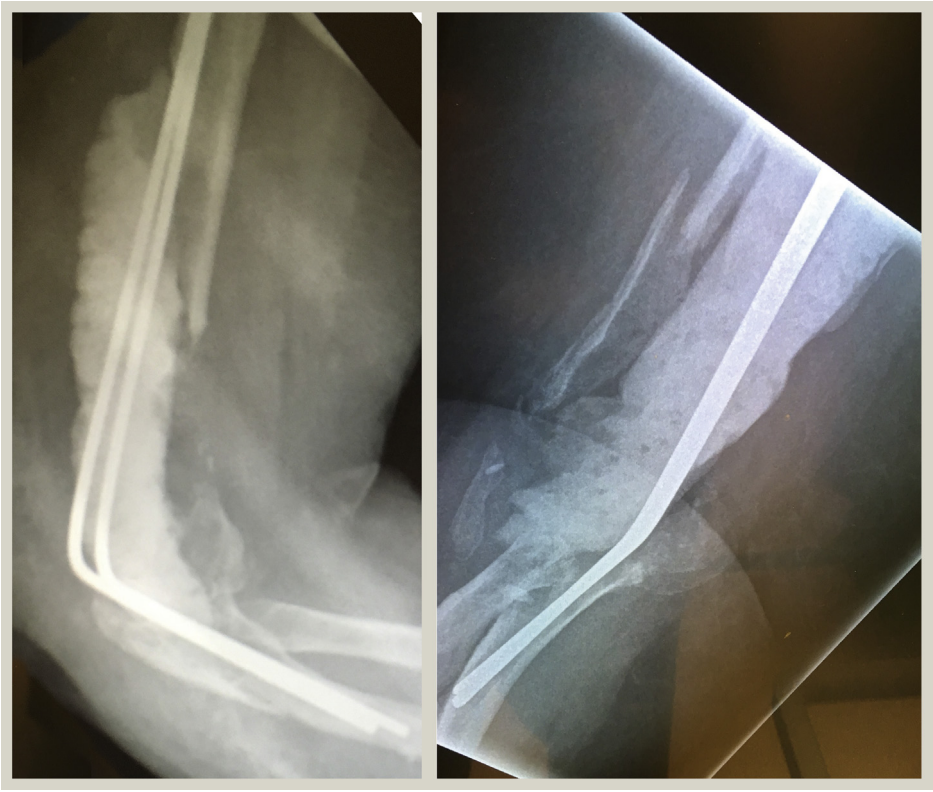

Figure 6 Radiographs showing a static cement spacer in-situ following a first-stage revision of an infected total elbow replacement with a 7-year-old non-union of a fracture at the tip of the stem that was unsalvageable, leading to massive bone loss.

Figure 7 Radiographs of segmental bone loss with a failed fixation following multiple operations to the distal humerus (left), and following the first-stage debridement and static cement spacer (right).

dependent on multiple factors; adequate debridement, high-quality microbiology sampling and handling, healthy soft tissue cover, appropriate antibiotic therapy (local and/or systemic) and an appropriately timed, meticulous second stage revision with re-implantation of a prosthesis.[16] As these cases are uncommon, revision TER for PJI should be carried out in regional hubs. Most units follow the same protocols and procedures but of course with some regional variation, especially in terms of the involvement of microbiology staff. Below, we describe the basic process of our routine two-stage revision.

The first stage

Surgery is performed under general anaesthesia and a regional block in our unit. The patient is placed in the lateral position with the arm supported on a narrow arm gutter. Intravenous antibiotics are not administered prior to the start of surgery, but in routine PJI work, 12 mg/kg of teicoplanin is given after the samples are taken intraoperatively. A posterior skin incision is used, utilising previous incisions and excising unhealthy skin as needed. Full-thickness skin flaps are raised and the ulnar nerve is identified then protected throughout. If not previously transposed, we routinely transpose the nerve at this stage to save time at the second-stage procedure and prevent the nerve from becoming stuck in any posterior scarring.

In addressing the triceps, one must ensure adequate exposure of the distal humerus and proximal ulna to safely remove the prosthesis and cement. If we can keep the triceps-on for the first stage that is our preference. If for exposure's sake we take the triceps off, we tend to favour a triceps tongue[17] (Figure 4) leaving a remnant of the triceps fascia on each side to aid a sound repair at the end of the case. As the joint is opened, any fluid present is sent as a sample. In addition we send tissue from the articulation of the prosthesis, the distal humerus, the proximal ulna and from intramedullary sampling of both bones. Each sample should be taken using fresh instruments and placed directly into a sterile pot. Once sampling is complete, the tourniquet is released and antibiotics are given. The prosthesis and the cement are removed using instruments specifically designed for the job. These include custom-made cement chisels, splitters and reamers. Revision surgery such as this should be carried out in specialist hubs that possess the training, skills and resources, including plastic surgery and vascular surgery assistance should it be required.

Once everything is removed, and after thorough lavage, a cement spacer is placed. These can be dynamic to allow elbow range of movement (Figure 5) or if there is gross instability expected due to bone loss, a static spacer with intramedullary instrumentation is used (Figure 6). In routine cases in which the organism is unknown, we use 2 g of vancomycin per mix of high viscosity cement with gentamicin and mould the spacer by hand. During closure, the triceps repair is vital to provide future function and strong healthy soft tissue coverage over the back of the elbow.

The second stage

The second stage is performed after a clear antibiotic-free period of at least 4 weeks, when the soft tissues are as good as possible and the blood parameters are normal. Some units repeat a biopsy or aspiration prior to second-stage revision surgery, but we rely on the clinical situation and blood tests alone. If there is still evidence of active infection (redness, warmth, discharge, raised inflammatory markers), then we consider repeating the first stage.

Second-stage surgery involves opening the same incision, providing adequate exposure and protecting neurovascular structures. With regards to the triceps, the triceps tongue can be repeated if good-quality tissues allow, although the Stanley approach[18] is incredibly safe, allows wide exposure of the joint and closes the soft tissues as a single envelope thereby isolating the replacement from the superficial layers of the elbow. The cement spacer is removed, if present, and deep samples are taken again prior to antibiotic administration with routine prophylaxis (intravenous teicoplanin and gentamicin). The implant is cemented in place with proprietary bone cement (incorporating clindamycin and gentamicin). We tend not to add additional antibiotics to the cement at the second stage, as nearly all infections are sensitive to this regime and the addition may change the mechanical properties of the cement, potentially compromising longevity of the fixation. Postoperatively we do not routinely place the patient on antibiotics but await the provisional culture results at 72 hours. If positive, the patient is placed on rifampicin (to address formation of biofilms) and other appropriate antibiotics (intravenous or oral) to attempt eradication rather than suppression. All decisions regarding antibiotic therapy should be in collaboration with a specialist

Figure 8 Radiographs showing a massive structural allograft (distal humerus) fixed to the native humeral shaft prior to insertion of a long-stem total elbow replacement as the second stage of the patient from Figure 6.

microbiologist who has an understanding of deep bone and joint infections. The best-case scenario is that all samples are negative in which case there is no need for further systemic antibiotics.

Dealing with bone loss in the presence of infection

The humerus and ulna are narrow, long bones with thin cortices. With aseptic loosening, the cortices thin quickly and are prone to periprosthetic fracture. In the presence of infection this effect is increased, causing osteolysis and frequently there is bone loss from the distal humerus or proximal ulna. In addition, expansile areas of osteolysis appear at the tips of loose stems, which are prone to iatrogenic perforation or fracture at the time of first stage revision. The first step in avoiding massive bone loss is taking care whilst removing the prostheses and cement at the first-stage revision. This is especially true if the prosthesis is well-fixed, as it is far more challenging to preserve all the remaining bone stock in these circumstances. Our advice would always be to create a window at or beyond the tip of the stem in a well-fixed stem as described previously.[19] The most difficult revisions involve an infected prosthesis that is reasonably well fixed with a fracture at the tip of the stem. Figure 6 shows massive bone loss in such a scenario, in which the distal humerus was not salvageable. Similarly, massive segmental bone loss can occur if deep infection is under-treated as in Figure 7, where the patient underwent multiple fixation procedures to try and salvage a distal humeral fracture but at no stage addressing the deep infection; the result was segmental osteomyelitis of the distal humerus. There is no clear evidence on the best course of management in these difficult and rare cases but in our unit we utilise either a structural allograft or an endoprosthesis.

Structural allograft prior to implantation of a TER is rarely performed in the UK. Figure 8 shows the second stage management of the patient from Figure 6 using a whole humeral shaft cut to the correct length, rotation and fit. Following this it was fixed in-situ and a long-stem cemented TER was implanted. This option is probably best in the very young (in this case 49 years old) to attempt to restore bone stock. Anecdotally, the allografts performed have rarely been able to truly restore bone stock due to unsuccessful host-allograft integration in the long term.[20] Endoprostheses and custom-made implants are becoming more commonly used due to their relative ease of insertion and the possibility of implant-host integration with the use of hydroxyapatite or porous coated collars; Figure 9 shows the second-stage management of Figure 7. There is no evidence as to which option is best to manage bone loss in the presence of infection, but both seem to be safe and function reasonably well. Second-stage outcomes largely depend on how well the first stage is performed.

Salvage procedures

Finally, in patients where two-stage revision is just not possible or the risk of a single-stage revision failing is too high, salvage procedures are indicated after discussion with the patient. These include resection arthroplasty, fusion or antibiotic suppression. Resection of the elbow is known to result in poor function and an unstable elbow. It has shown some success when the medial and

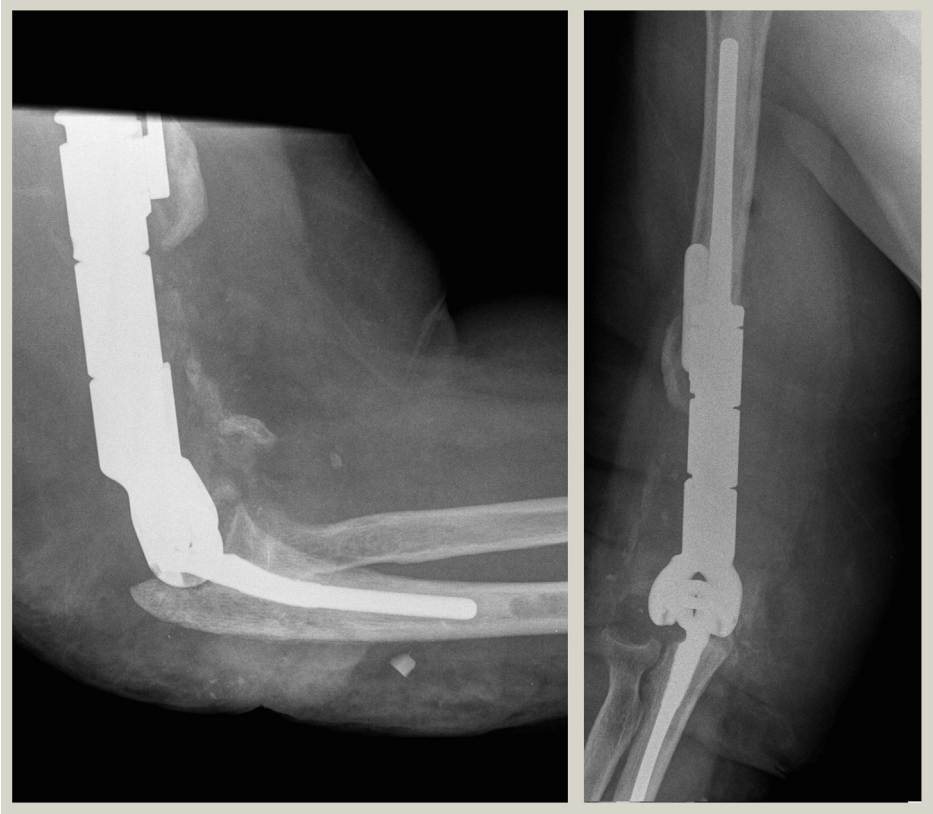

Figure 9 Radiographs showing an endoprosthesis total elbow replacement as the second-stage procedure in the patient from Figure 7.

lateral condyles are intact to provide a fulcrum for the ulna remnant to hinge around. A fusion is difficult to achieve, as frequently the patients in whom this is considered to be appropriate have significant bone loss.[21] In addition, to achieve a fusion some form of internal fixation is usually required, which leads to bacterial colonization of the plate. Antibiotic suppression is probably the most appropriate treatment for those patients who are not fit or appropriate for two-stage revision, especially if the soft tissues are intact and the organism and sensitivities are known. In some rare cases where the prosthesis is exposed, cover using local tissue flaps followed by antibiotic suppression is another appropriate course of action.

Conclusion

The management of periprosthetic infection in the elbow follows similar principles to those established in other joints and those principles can be extended to the management of infection in the native elbow requiring joint replacement and suspected infection. The prime consideration in such rarely performed surgery is whether the surgeon possesses the experience, skills and support needed to ensure as high a success rate as possible, and this is only usually possible in a centre performing a reasonable number of such procedures annually. ◆

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