Surgical strategies for management of infection following knee arthroplasty and arthroscopic procedures

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Abstract

Infection is one of the most feared complications following knee arthroplasty and soft tissue arthroscopic procedures. This article summarizes the current understanding on the management of this rare but devastating problem. The healthcare and economic burden of periprosthetic joint infection (PJI) is highlighted, together with how the classification of infection and host staging can aid decision-making. Surgical treatment options will be described. These consist of 'debridement, antibiotics and implant retention' (DAIR), revision arthroplasty (single- or two-stage), as well as salvage procedures (arthrodesis, permanent resection, and amputation). In selected cases, chronic antibiotic suppression may be the only viable option. All implant-related orthopaedic infections must be managed using a multidisciplinary team (MDT) approach, ideally within dedicated bone infection units, in order to optimize clinical outcomes.

Keywords DAIR; implant retention; irrigation and debridement; knee arthroplasty; knee arthroscopy; periprosthetic joint infection; revision arthroplasty; surgical management

Introduction

Deep infection following knee arthroplasty or soft tissue arthroscopic procedures is one of the most feared complications and is potentially catastrophic. The incidence of septic arthritis after simple arthroscopic procedures (e.g. meniscectomy, meniscal repair, or microfracture) is extremely low and reports range from 0.009% to 1.1%.[1] More complex procedures that involve implantation of a foreign material, for example anterior cruciate ligament reconstruction (ACLR), carry a higher risk of septic arthritis (0.14–1.7%).[2] This complication can result in significant patient morbidity with the need for hospital re-admission, repeat surgery and long-term antibiotic administration.[1,3] The incidence of periprosthetic joint infection (PJI) after primary total knee arthroplasty (TKA) is also low, with national estimates from around the world ranging between 0.85% and 2.2%.[4–8] The incidence of PJI after revision TKA is substantially higher with national estimates reaching 10%.[9] Analysis of the National Joint Registry (NJR) for England and Wales demonstrates that the second most common indication for revision TKA (after revision for loosening) is revision for infection (14.8% of revisions).[10] Figures from the U are even more alarming with PJI being the most common reason for revision TKA (25% of revisions).[11] Recent data from the NJR also suggest that the prevalence of revision for PJI has increased 2.5-fold for primary TKA and 7.5-fold for revision TKA between 2005 and 2013.[12] The increasing burden of PJI will place substantial pressure on healthcare providers and stretch healthcare resources due to the complex nature of PJI management.[13,14] In addition to this economic burden, PJI has a significant health burden associated with it. Multiple procedures, increased complication rates, long-term antibiotic use and prolonged hospitalization can result in significant pain and distress for patients. Ultimately, PJI can result in loss of function, amputation and even death. The significant morbidity and mortality associated with PJI has been highlighted in recent years.[15–18]

The cornerstone of PJI management is prevention, but accurate diagnosis and treatment are essential to optimize outcomes. Significant progress has been made in these domains over the past two decades. Developments encompassing all areas of musculoskeletal infection were recently presented and discussed at the Second International Consensus Meeting (ICM) on Musculoskeletal Infection that was held in Philadelphia during July 2018.[19] The reader is encouraged to access the website for a review of information on every aspect of managing musculoskeletal infections. Arguably the most important aspect is that they should be managed within dedicated multidisciplinary teams (MDTs) using evidence-based protocols.[20–22] Orthopaedic surgeons must be aware that these are complex and challenging cases that necessitate the involvement of other MDT members such as infectious disease physicians, plastic surgeons, specialist infectious disease nurses, radiologists and anaesthetists. This review will focus on surgical aspects of managing infection after knee arthroplasty and soft tissue arthroscopic procedures.

Classification

Traditionally, PJI has been classified based on chronicity into 'early/acute', 'acute haematogenous', and 'late/chronic' infections.[23,24] Early infections are those occurring within about 3–4 weeks of index surgery and are often the result of peri-operative contamination. Acute haematogenous infections can occur at any time after implantation and are a result of haematogenous seeding from distant sites in a previously well-functioning implant. All other infections are considered to be late infections. It is important to note that this classification has

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no relevance to the stability of the implant. The rational for this classification is based on the ability of bacteria to form a mature biofilm to shield them from antibiotic treatment, thus making PJI eradication more challenging. This biofilm formation commonly occurs within a few weeks. However, there have been recent calls from experts in the field for a move away from this arbitrary division based on time in order to consider PJI as a continuum.[25] The proponents of this recommendation cite recent evidence that suggests biofilms can form in a very short time after bacterial inoculation. Some *in vitro* studies suggest that biofilms form within a few hours of bacterial inoculation.[26] However, most *in vivo* animal model studies, which take into account the protective effects of the host immune system, suggest that it takes approximately 2–6 weeks for mature biofilms to form.[27–29] Implant salvage and PJI eradication utilising a debridement, antibiotics and implant retention (DAIR) protocol is more easily achieved before the formation of a mature biofilm and hence early or acute haematogenous infections often lend themselves to this type of surgical management. However PJI eradication and mature biofilm formation also depend on the type of bacteria as well as a number of complex host factors. This is why there is recent debate about the limitations of a time-based classification of PJI since the time points in the course of infections can often be difficult to pinpoint and some patients may not complain of specific longstanding symptoms prior to presenting as a 'chronic' infection.

Nevertheless, this classification can be a useful guide in most circumstances if the surgeon uses common sense in conjunction with all other important information relating to the case in order to guide surgical treatment.

A useful grading system, which has gained popularity over recent years, is the host staging system proposed by McPherson et al.[30,31] This staging system takes into account three important domains: i) timing of infection; ii) the host's systemic medical and immune status; iii) local compromising factors of the affected limb (Table 1). Emerging data suggest that there is a correlation between the McPherson staging system and treatment success, both in terms of PJI eradication and functional outcome.[30–33] We therefore recommend that readers use this staging system as a method of risk stratification to aid decision-making.

Management options

Chronic antibiotic suppression

Although the gold standard for the treatment of PJI is surgical management, chronic antibiotic suppression (CAS) may be the only option in a small and selected group of patients. This includes patients who are unwilling to undergo any further surgical intervention and severe high-risk patients who are medically unfit or too frail to undergo surgery.[34] It may also be an option in cases where surgery is not likely to improve the patient's functional outcome, such as in cases of multiple previous failed attempts at PJI eradication. In such cohorts, one accepts that the infection may never be fully eradicated but chronic suppression can help reduce the bioburden to such a level that the host's own immune system is able to keep the infection at bay. There are a number of criteria that must be fulfilled in the above groups of patients in order to consider CAS. These include:

- a well-fixed implant
- availability of an oral choice of antibiotic for the infecting organism
- presence of a low-virulence organism
- ability of the patient to tolerate oral antibiotics.

In addition to the above criteria, the presence of another foreign uninfected implant, such as an artificial heart valve or orthopaedic implant, is a relative contraindication to CAS. There is limited literature on the effectiveness of CAS and success rates are very variable, ranging between 18% and 86%.[35–38] Although by definition, this treatment modality involves lifelong antibiotic suppression, many patients are unable to comply with this regime due to medication intolerance.

Debridement, antibiotics and implant retention (DAIR)

Open DAIR is an attractive surgical management option for an infected implant because of its potential to cause less bone and soft tissue destruction in comparison to a formal one- or two-stage exchange arthroplasty. This is why the functional outcome following DAIR has been reported to be equivalent or superior to revision arthroplasty.[39,40] Although DAIR is arguably a technically easier procedure than revision TKA, it is important to note that it should not be viewed as a temporizing emergency procedure, which can be performed 'out-of-hours' by an inexperienced surgeon. The authors strongly support the notion that DAIR should be an urgent but planned procedure that is performed (or directly supervised) by an experienced arthroplasty surgeon.[41] This procedure should be viewed in the same manner as a formal revision arthroplasty but with more rapid preoperative optimization of the host and identification of an infecting organism where possible. In addition, the results of arthroscopic washout have been shown to be inferior compared to open DAIR and recent international guidelines advise against the use of arthroscopic surgery.[42,43]

Although there are many factors that influence the successful outcome of DAIR, the procedure can be considered suitable in cases where the implants are well fixed, well positioned, there is a good soft tissue envelope, and the joint has been functioning well prior to the infection.[44] Absolute contraindications to DAIR are the presence of a draining sinus or the inability to close the wound.[45] There is also a general consensus that DAIR should only be performed for early and acute haematogenous infections.[41] As previously mentioned, this is thought to be due to the reduced likelihood of mature biofilm formation in such cases.[27] Although some authors have reported favourable PJI eradication rates in chronic cases, the success rate for chronic PJI remains inferior in comparison to early infections.[46] However, there is currently insufficient evidence to recommend a specific time limit beyond which DAIR should not be performed.

Review of the existing literature demonstrates vast variability (16–100%) for the success rate of DAIR for knee PJI eradication.[47] Unfortunately there is significant heterogeneity within these studies. A recent systematic review and meta-analysis of treatment outcomes for DAIR estimates infection control to be 52.6% for knees in comparison to 75.4% for hips.[48] It has been postulated that the inferior outcome in knees (compared to hips) is due to the poorer surrounding soft tissue envelope. Exchange of modular components (i.e. polyethylene bearing), because it reduces the bioburden, as well as allowing access to the posterior

McPherson staging system for periprosthetic joint infection

Grading	Category	Description	
Infection type	I	Early (<4 weeks)	
	II	Acute haematogenous	
	III	Late	
Systemic host grade	A	No compromising factors	**Compromising factors (medical and immune):**
	B	Compromised (one or two compromising factors)	• Age >80 years • Alcoholism
	C	Significant compromise (more than two factors) or one of following: • Absolute neutrophil count <1000 • CD4 T cell count <100 • Intravenous drug abuse • Chronic active infection other site • Dysplasia or neoplasm of immune system	• Chronic active dermatitis or cellulitis • Chronic indwelling catheter • Chronic malnutrition (albumin <3.0 g/dl) • Current nicotine use (inhalational or oral) • Diabetes (requiring oral agents and/or insulin) • Hepatitc insufficiency (cirrhosis) • Immunosuppressive drugs (methotrexate, prednisone, cyclosporine) • Malignancy (history of, or active) • Pulmonary insufficiency (room air arterial blood gas $O_2 < 60\%$) • Renal failure requiring dialysis • Systemic inflammatory disease (rheumatoid arthritis, systemic lupus erythematosus) • Systemic immune compromise from infection or disease (human immunodeficiency virus, acquired immunodeficiency virus)
Local extremity grade	1	Uncompromised (no compromising factors)	**Compromising factors:**
	2	Compromised (one or two compromising factors)	• Active infection present > 3–4 months • Multiple incisions (creating skin bridges)
	3	Significant compromise (more than two compromising factors)	• Soft tissue loss from prior trauma • Subcutaneous abscess >8 cm^2 • Synovial cutaneous fistula • Prior periarticular fracture or trauma about joint (especially crush injury) • Prior local irradiation to wound area • Vascular insufficiency to extremity (absent extremity pulses, chronic venous stasis disease, significant calcific arterial disease)

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Table 1

capsule for debridement, and has been shown to improve infection eradication.[41] Other factors that increase the likelihood of failure include: prolonged duration of symptoms, the causative pathogens (e.g. worse outcomes with fungal and multi-drug resistant species), severe/extensive infections, and poor host immune status (including conditions such as rheumatoid arthritis, chronic renal failure and liver cirrhosis).[41,44] Awareness of these factors will allow surgeons to better risk stratify cases that may be suitable for a successful DAIR.

The surgical technique for performing DAIR is critical to optimize the outcome. The preferred technique of the authors is summarized below and is based on the recent literature and published ICM guidelines.[41,44,45,49] Following rapid medical optimization of the patient, the patient undergoes surgery by an experienced revision arthroplasty surgeon as a planned but urgent procedure. An open arthrotomy is performed to achieve good visualization of the joint and the previous incision edges are excised. Five paired samples of deep tissue are sent for microbiological and histological analysis. The tissue–implant interface is carefully inspected to confirm stability of the implants. If at this point, either of the tibial and/or femoral components are found to be loose, DAIR is abandoned and a revision arthroplasty is performed. If the implants are stable, the modular tibial polyethylene insert is removed where possible to gain access to the posterior capsule. This is later replaced by a new insert. The posterior capsule and gutters are debrided. Necrotic tissues, inflamed synovium and loose bone or cement fragments are also excised. The joint and wound are thoroughly washed with 6−9 litres of 0.05% aqueous chlorhexidine using pulsed lavage. (Normal saline is recommended for washout of unicompartmental knee arthroplasties due to the risk of damage to native cartilage by chlorhexidine). The surgical team then rescrubs and redraping takes place. New, clean instruments are used to wash the joint again with 3 litres of saline, the new polyethylene liner is inserted and wound closure is performed using monofilament sutures. A deep drain is commonly used and is removed at 48 hours. We are currently evaluating the role of resorbable antibiotic impregnated pellets for local antibiotic delivery but there is currently no conclusive evidence that they alter clinical outcome and their routine use is not recommended by current ICM guidelines. Postoperatively, patients are placed on broad-spectrum antibiotics that are subsequently altered according to culture results. All patients are managed with the help of dedicated infectious disease (ID) physicians who are also involved in the long-term outpatient clinical follow-up.

Due to the complexity and heterogeneity of PJI, antibiotic regimens should be administered under the guidance of ID physicians and should take into account all the risk factors described above. As result of this complexity, there is considerable debate with regards to the optimal length of time for antibiotic treatment. Although traditionally knee PJIs were treated for at least 6 months with antibiotics, emerging literature and current guidelines seem to suggest that approximately 8 weeks of therapy may be adequate in the majority of cases.[41,44]

Single-stage exchange arthroplasty

Ever since its introduction in 1981 by Bucholtz and colleagues from The ENDO-Klinik in Hamburg, single-stage exchange arthroplasty has been the favoured treatment option by many specialized centres − especially in Europe.[50] It has recently gained more popularity worldwide due to the perceived advantage of being a single procedure with equivalent PJI eradication rates to a two-stage procedure, but with reduced patient morbidity, mortality, and hospital resource use.[51] However, the success of one-stage arthroplasty is dependent on the application of strict surgical protocols as well as several important selection criteria.

There are a number of host, local limb and microbiological factors that are thought to be important achieving a successful outcome in one-stage exchange. However, these have all been identified based on retrospective or prospective observational studies and no randomized controlled trials have yet evaluated these factors. Based on the existing literature, the generally accepted indications for one-stage exchange are:[51]

- known infecting organism identified preoperatively
- known susceptibility to available antibiotics
- a healthy uncompromised host
- absence of severe sepsis and haemodynamic compromise, which necessitates an emergency procedure to remove hardware and reduce the bioburden
- absence of severe bone and soft tissue damage that would otherwise compromise primary wound closure.

There are also a number of relative contraindications to one-stage exchange:

- culture-negative infections in which appropriate antibiotic treatment cannot be determined
- highly virulent or multi-resistant organisms especially those for which no local antibiotic treatment options are available
- infections with fungal organisms
- cases in which radical debridement may not be possible such as infections involving major neurovascular bundles
- failure of one or more previous one-stage procedures.

It must be noted that highly specialized centres have demonstrated favourable results without complying with some of the above indications and/or contraindications.[52−55] However, in the absence of high-quality trials, we would advocate that surgeons follow the recommended indications have been proposed.

Even though meticulous and radical surgical debridement is a key component of this procedure, many surgical aspects of one-stage exchange require the involvement of the MDT. The infectious disease physicians play a vital role in determining the type and dosage of systemic and local antibiotics that should be used. Plastic surgeons may also be called upon to help with closure of soft tissue defects and the wound. Surgery involves careful excision of the old scar, as well as any sinus tracts. It may be necessary to use extensile exposure techniques such as a tibial tubercle osteotomy or quadriceps snip in order to obtain adequate access to the joint. All components, including the patella button, should be removed. Specialized revision surgery instruments commonly used include a small oscillating saw (to break the cement mantle), flexible narrow osteotomes, high-speed burrs, and cement removal instruments such as drills, an ultra-sonic cement removal device and long handle rongeurs. Following component and cement removal, five paired samples of deep tissue should be sent for microbiological and histological analysis. This should include samples from the intramedullary canals as well as the posterior capsule. Meticulous debridement of all membranes, devitalized bone and soft tissue should be carried out. Pulsed lavage irrigation of the joint and the intramedullary canals with 0.05% aqueous chlorhexidine or other antibacterial solutions is performed. The joint and medullary canals are packed with aqueous chlorhexidine soaked swabs and the wound is temporarily closed with interrupted sutures. Redraping is performed and the surgical staff rescrub and regown. Joint reconstruction is then performed with the new prosthesis being implanted in the standard fashion. Prostheses have commonly been implanted using antibiotic-loaded cement in order to provide local antibiotic delivery against the infecting organism. The antibiotic used must be heat stable and not exceed 10% of the weight of the polymethylmethacrylate (PMMA) powder in order to prevent biomechanical weakness of the cement. Reconstruction will often involve the use of a semi-constrained or hinged prosthesis due to bone loss or ligament insufficiency. Other adjuncts such as metaphyseal sleeves and cones can also be used depending on the surgeon's preference. Some authors have reported promising results using a combination of cementless prostheses and antibiotic-impregnated bone allograft but data surrounding this technique are limited.[56] Post-operative antibiotic therapy should be based on the antibiogram of the infecting organism and administered under the guidance of infectious disease physicians. This usually consists of up to 10−14 days of intravenous antibiotics followed by oral antibiotics. It most cases, 4−6 weeks of antibiotic therapy is thought to be sufficient but this needs to be individualized based on the host immune status, organism virulence, complexity of the procedure and the status of the soft tissue.[57]

With regards to the outcome of single-stage and two-stage surgery, there is a paucity of high quality studies available. In the absence of any randomized controlled trials, conclusions can only be based on retrospective and prospective observational studies and their meta-analysis. In terms of infection eradication, recent systematic reviews and meta-analyses suggest that there is no difference in outcome between the two procedures.[58,59] The pooled results demonstrate that re-infection rate was 7.6% (95% confidence interval 3.4−13.1) in single-stage studies compared to 8.8% (95% confidence interval 7.2−10.6) in two-stage studies. Despite the limitations of the available studies, when performed for the correct indications, one-stage exchange appears to have the advantage of lower morbidity, mortality and overall cost.[51]

Two-stage revision arthroplasty

Two-stage exchange arthroplasty continues to be viewed by many as the 'gold standard' treatment for chronic infections and is favoured by many institutions − particularly in North America. In short, the indications for two-stage exchange can be thought of as the contraindications for one-stage surgery:

- severe sepsis and haemodynamic compromise
- culture-negative infections
- infections with highly virulent or multi-resistant organisms
- infections with fungal organisms
- cases with severe bone and soft tissue damage which compromises primary wound closure
- cases in which radical debridement may not be possible such as infections involving major neurovascular bundles
- failure of one or more previous one-stage procedures.

This treatment option involves two separate operative procedures separated by a period of weeks to months. During the first stage, implant removal and tissue sampling is followed by radical debridement and irrigation (similar to single-stage exchange described above). After redraping, an antibiotic-loaded cement spacer is implanted into the joint. The purpose of the spacer is to deliver high-dose antibiotics locally, as well as providing knee stability and maintaining the joint space for the subsequent second stage. This can be an 'articulating' or 'static' spacer. There is considerable debate with regards to the different merits of either type. Although there is no difference in terms of the ability to eradicate infection, proponents of articulating spacers believe that they prevent muscle contracture, incur less functional limitation and provide better range of movement.[60] Static spacers are recommended in cases of severe bone loss or collateral ligament insufficiency. Maintaining the joint in extension also enables wound rest and is indicated following reconstruction of severe soft tissue defects with flaps. Some surgeons prefer to use silver-coated or low-cost implants with a cobalt chrome femoral component and an all polyethylene tibia but very few studies have compared their outcome with that of regular cement spacers. The antibiotics used in cement spacers should be heat stable and ideally target the infecting organism if this has already been identified. The overall aim, however, is to provide broad-spectrum coverage and a combination of vancomycin and an aminoglycoside (e.g. tobramycin or gentamycin) is commonly used. Large concentrations of antibiotics (up to 20% of total spacer mass) can be used, as mechanical properties of the cement are not the greatest concern in this situation. Care should be taken to prevent systemic toxicity and advice should be sought from infectious disease physicians prior to dosing. Antibiotics should be hand mixed rather than under vacuum, as the air bubbles in the cement allow better antibiotic elution into the joint by increasing the surface area. The spacer should be cemented in 'badly' in order to prevent extreme cement to bone interdigitation, facilitating its removal at the second stage.

Postoperatively, patients are placed on broad-spectrum antibiotics until the definitive cultures become available. The subsequent type and duration antibiotic treatment should be guided by the advice of infectious disease physicians. The duration of antibiotic treatment continues to be debated and studies have not been able to establish a conclusive timeframe. However, most guidelines suggest that a period of 4−6 weeks of antibiotic therapy (either intravenous, oral, or a combination of the two) after the first stage is sufficient.[61] This can be highly specific and will depend on the microorganism profile, drug side effects, and patient tolerance. Close attention must be paid to clinical and laboratory parameters during this period but surgeons must be aware that inflammatory markers may not be elevated in cases infected with low-virulence organisms. Another hotly debated topic is the timing of re-implantation. No conclusive time frame has yet been defined and it is recommended that the treating medical team make this decision based on an individual patient basis when they are certain that there is no residual infection.[62] In most recent studies, this is performed between 6 weeks and 3 months but this decision should be based on a combination of clinical and laboratory parameters. In addition to measurement of inflammatory markers, some institutions also perform joint aspiration and synovial fluid analysis but the accuracy of all these laboratory tests in this situation has been questioned. Although the evidence-base for this is inconclusive, many institutions also advocate an 'antibiotic holiday' period of at least two weeks prior to re-implantation.[63] If there is any indication to suggest that there is residual infection, a repeat first stage should be performed. The second stage provides another opportunity for radical debridement, irrigation, and further sampling. As in single−stage surgery, redraping is performed prior to implantation of the new prosthesis. Reconstruction takes place in a similar manner to single-stage exchange, as described earlier. Postoperative antibiotics are usually continued until negative intraoperative culture results are available (usually at 48−72 hours). If the culture results are positive, there may be a case for further long-term antibiotic treatment. Although it is not our routine practice, there is some recent evidence to suggest that an extended 3-month period of oral antibiotic prophylaxis may reduce the risk of subsequent failure.[61] This may be worth considering in high-risk cases or in frail individuals who will be unable to tolerate a further revision procedure.

As stated earlier, there appears to be no difference between one- and two-stage surgery in terms of infection eradication. However, two-stage surgery appears to have greater morbidity, mortality and cost associated with it.

Salvage procedures

Preservation of the implant and joint function may not be an option for a small number of patients with multiply failed exchange arthroplasties and the persistence of infection who are not candidates for further revision surgery. For these individuals, the only option for infection management and some improvement in quality of life is to undertake a salvage procedure.

Permanent resection arthroplasty

Joint resection and debridement without implantation is the least common salvage procedure. It is reserved for patients who do not wish to undergo an amputation and who are not candidates for an arthrodesis. This includes sedentary patients with multiple comorbidities, which preclude them from ambulation even if they were to undergo an arthrodesis or amputation. However, the resultant disability caused by an unstable and often painful limb is often distressing.[64]

Arthrodesis

Knee arthrodesis (fusion) is the most common salvage procedure. In comparison to above knee amputation, it provides superior functional results.[65] As a result, young and active patients are likely to benefit more from arthrodesis. It is indicated in patients with treatment failure following multiple previous attempts at revision arthroplasty, such as those with multi-resistant organisms. It also includes those with poor bone stock or extensor mechanism dysfunction who are not suitable for joint reconstruction. However, in some multiply revised cases, it may not be technically possible due to poor available bone stock. In addition to adequate debridement, rigid fixation and maintenance of bone stock is key to successful fusion and infection eradication. Bone cuts should be made in 5–7° of valgus alignment and the consequent limb shortening flexion allows the foot to clear the ground when walking. The most common methods of fixation are either with an external fixator or an intramedullary nail. Intramedullary nails allow earlier weight bearing and have a higher reported rate of fusion, but carry the risk of recurrent infection due to the retained hardware. External fixation poses some limitation to function prior to its removal but poses no risk of future hardware related infection. Extended antibiotic therapy for 4–6 weeks is recommended following surgery. The reported infection eradication rate with intramedullary nailing was 91.7% in comparison to 95.1% with external fixation.[66]

Amputation

Above-knee amputation (AKA) is considered as a last resort when other reconstructive options have been exhausted or rarely in cases of severe uncontrolled sepsis that cannot be controlled with prosthesis removal alone. It may be necessary in cases of severe bone loss where arthrodesis is not technically possible. AKA is also indicated in cases with severe soft tissue involvement and in cases where primary wound closure is not possible. Due to the high energy expenditure required for walking following AKA, many elderly patients will not regain independent ambulation and will be wheelchair bound.[65]

Surgical treatment of septic arthritis following arthroscopic procedures

Infection following simple knee arthroscopy

Septic arthritis is a rare but extremely serious complication following simple knee arthroscopic procedures (e.g. meniscectomy, meniscal repair, or microfracture). It can result in systemic sepsis, mortality and future degeneration of the joint. Following urgent optimization of the patient, treatment should commence without delay – preferably on the same day. Arthroscopic lavage, as opposed to open arthrotomy, is the preferred method of initial treatment. As previously described for PJI, multiple synovial tissue biopsies should be taken for microbiological and histological analysis. Copious amounts of saline (between 10 litres and 15 litres) should be used to wash out joint debris and reduce the intra-articular concentration of chondrolytic enzymes.[19] The available literature does not support the routine use of intra-articular antibiotic solutions. There is a paucity of data regarding the role of partial or total synovectomy but some studies support its use in severe or chronic infections (Gaechter stage III and IV).[19] There is continued controversy over the optimal duration and route of antibiotic therapy following surgery. The available literature suggests that antibiotic therapy should be administered for 4–6 weeks and continued until resolution of clinical and laboratory parameters. The decision to convert from intravenous to oral antibiotics depends on the type of microorganism involved as well as host factors. As always, this should be conducted under the guidance of infectious disease physicians. Repeat arthroscopic lavage is indicated if clinical and laboratory parameters suggest persistence of infection, usually after 2–3 days. There is a paucity of literature to provide a clear guidance on the maximum number of arthroscopic washouts. This depends on the infecting microorganism, the host, and the severity of infection. With prompt treatment, Infection eradication rates are very satisfactory with many studies reporting 100% eradication rates.[1]

Infection following complex arthroscopic procedures

Most of the literature surrounding infection following complex arthroscopic procedures concerns infections following anterior cruciate ligament (ACL) reconstruction. These infections are more challenging to treat due to the complicating factors of retained hardware, tendon allografts, and concerns regarding failure of the reconstruction. As with infection following simple arthroscopy, the treatment of choice consists of prompt arthroscopic lavage followed by systemic antibiotic therapy for approximately 4–6 weeks. Similarly, repeat surgical intervention is recommended for infection persistence. A recent systematic review of 11 eligible studies demonstrated that repeat washout is necessary in 34.5% of cases.[67] Graft and hardware removal is generally advised for infections that require more than two arthroscopic washouts.[19] Delayed presentation of beyond 7 days and *Staphylococcus aureus* infections have been shown to increase the likelihood for graft removal and poor range of movement.[2] The available literature estimates an infection eradication and graft salvage rate of approximately 85%.[67,68] The available literature suggest that even despite successful infection eradication, there may be some minor reduction in functional outcome and possibility of early degenerative changes.[69]

Conclusions

Infection following knee arthroplasty and arthroscopy is a dreaded complication and prevention is the best method of combating this problem. Treatment is extremely challenging and often involves surgery but the key to success is an MDT approach. Further high-quality studies, in particular adequately powered randomized controlled trials, are desperately needed to determine the best treatment modalities. ◆

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