■ THE INFECTED KNEE ARTHROPLASTY

Single stage revision

REGAINING MOMENTUM

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In this paper we make the case for the use of single-stage revision for infected knee arthroplasty.

Infection is a challenging and complex complication for the arthroplasty surgeon. The mean infection rate for all joint arthroplasties is 1.25%.¹ The total hip arthroplasty (THA) infection rate ranges from 0.55% to 2.4%¹ whilst the total knee arthroplasty (TKA) infection rate ranges from 0.6% to 1.77%.¹ The infection rate has been fairly constant over the past few decades but with an increasing number of arthroplasties² being performed, the number of infected prosthesis will increase. The current gold standard for treating an infected hip or knee arthroplasty is to perform a two-stage revision. This is a costly process in terms of time and money, requiring a prolonged hospital stay and two operations.

Single stage revision has traditionally been thought to lead to an increased risk of further infection.³ This paper sets out the rationale for using single stage as a viable alternative to two-stage revision.

Two-stage revision

Parental antibiotics may eradicate planktonic bacterial infection and prevent further infection but prosthetic joint replacement infections are harder to eradicate due to the production of biofilm by the bacteria. The time taken for the biofilm to form is still debated but is thought to be between 36 hours to three weeks.⁴ Biofilm has a dual function; preventing antimicrobial agents penetrating it, whilst also allowing the underlying bacteria to replicate as an organised unit.⁴

Two-stage revision addresses the biofilm by removal of the implant with a through debridement and lavage, followed by closure with an antibiotic impregnated polymethylmethacrylate spacer *in-situ*. The cement spacer provides a high concentration of antibiotics to the local area, penetrating the biofilm and ensuring the joint is held with a degree of stability. Any further bacteria may be eradicated by intravenous antibiotics based upon bacterial

sensitivities for six weeks. Haematological inflammatory markers are also checked regularly to ensure progress. The second stage is performed after significant healing has occurred, which is usually within three months and the components are implanted with antibiotic loaded cement.⁵ The complications of a two-stage revision are: reduced mobility,⁶ spacer fracture,⁷⁻⁹ bone destruction,^{10,11} instability^{10,12} and contracture.¹³ Despite this, two-stage revision has been the gold standard for management of infected arthroplasties and has a 94% to 96% success rate¹⁴⁻¹⁷ in the literature. This high success rate is because two-stage revision provides the surgeon with two opportunities for debridement. The interval period allows the patient's response to antibiotics to be assessed, allowing the second stage to be performed at exactly the right time. The revision operation then allows a cementless implant to be inserted and allograft to be used if required.

Single-stage revision

Single-stage revision is a viable alternative to two-stage revision under certain conditions.¹⁸ At our institution single-stage revision is carried out when patients present with: minimal/moderate bone loss, non-immunocompromised patients, healthy soft tissues, a known organism with known sensitivities and when appropriate antibiotics are available. The operation is split into two parts; the first consists of a standard debridement, removal of all the components and cement, during which five samples are sent to microbiology, and a very thorough 15 litre lavage. The area is then soaked in aqueous betadine and the wound edges approximated. This is considered to be the end of the first operation and the patient is redraped and new instruments are used. The surgical team rescrubs and put on new gowns. After a further lavage, implantation of a new

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Table I. Infection classification system based upon clinical presentation³²

Type	Presentation
1	Positive intraoperative cultures
2	Acute post-operative infection
3	Acute haematogenous infection
4	Late chronic

prostheses is performed using antibiotic loaded cement or antibiotic loaded bone graft as needed. Post-operatively the patient requires a further five days of IV antibiotics and is converted to oral antibiotics once microbiology results are available. These antibiotics are continued for six weeks, with serial ESR, CRP and nutritional markers performed. This protocol has led to no further infection presenting in 97% of these highly selected cases with a minimum of 24 months follow-up.

The results from our institution are in keeping with the current literature. Moyad, Thornhill and Estok¹⁹ performed a literature review and looked at > 1200 joints from 12 studies and found that single stage revision has a 83% five year infection free rate. Buechel²⁰ reviewed 22 infected TKAs and found a 90% ten year infection free rate. Joulie et al¹ looked at 95 patients with THA or TKA infections with *Staph. Aureus*. A total of 16 underwent single-stage revision for THA, while 22 underwent the traditional two-stage revision. There was a 94% healing rate for the single stage *versus* an 86% healing rate for the two-stage revision. These results were biased as the surgeons performed a two-stage revision for patients who had undergone previous surgery and failed to eradicate the infection. Brandt et al²¹ found no difference between healing rates for THA and TKA between single stage revisions and two stage revisions. Vielpeau²² found the same healing rate between one- and two-stage revisions. Winkler²³ performed 37 single stage revision THAs that had bony defects using uncemented implants and antibiotic impregnated allograft. The antibiotic was Vancomycin for single organism infections and Vancomycin + Tobramycin for mixed infections. He found a 92% 4 year infection free rate. Raut²⁴ followed up 183 single stage revisions for infected THRs over seven years and found a 84% success rate. Raut²⁵ then looked at 57 discharging sinuses, treated with a single stage revision and found a 86% success rate. Ure²⁶ followed up 20 patients over 10 years and found no reinfections. Callaghan²⁷ followed up 24 patients over 10 years and found a 92% success rate.

Other factors that may reduce the reinfection rate following revision of a THA or TKA are: infection in a THA rather than TKA, infection in a cementless implant, bacteriology known prior to surgery, revision of the components rather than a lavage, prescription of adapted probabilistic post-operative antibiotics, monomicrobial infection rather

than polymicrobial infections, and patient factors such as adequate soft-tissue, use of immunosuppressants or significant co-morbidities.¹

Discussion

An infection in a THR results in a cost 2.8 times higher than if the components suffered from aseptic loosening and 4.8 times higher than a primary THR.²⁸ This represents a loss of \$15,000 to \$30,000 in the USA.¹⁹ The infection also carries an increased mortality rate of 0.4% to 1.2% for 65 year old patients and 2% to 7% for 80 year old patients.³⁰ A single-stage revision will reduce the cost of the procedure and its associated morbidity by reducing the length of hospital stay, improving the mobility and improving the post-operative pain.³¹

The largest issue for successful eradication of the infection is the production of biofilm by the bacteria, which forms between 36 hours and three weeks,⁴ preventing antimicrobial agents from penetrating through to the underlying bacteria. Antibiotic loaded cement provides a high local concentration for the first two days but this falls to very low levels after 72 hours. This low level might promote antibiotic resistant bacteria.⁵ The use of Vancomycin impregnated allograft has been shown to have a biphasic release over two to eight weeks, providing high enough local concentrations to penetrate the biofilm and eliminate the bacteria.²³ Winkler used this technique in 37 infected THRs and had a 92% medium term success rate.²³

Haddad³² described a classification system based upon the clinical presentation of a patient with suspected deep periprosthetic infection (Table I). The classification system looks to treat the infection based upon the grading. Grade I requires two or greater positive intraoperative cultures and is managed with appropriate antibiotic therapy based upon the sensitivities of the cultures. Grade II infections are those that develop within the first month and is managed with an attempt at debridement and prosthetic retention. Grade III infections present with acute symptoms in a previously well functioning joint and are managed with an attempt at debridement and prosthetic retention but prosthetic removal might be necessary. Grade IV infections are chronic indolent infection presenting less than one month post-surgery and necessitate prosthetic removal.

Conclusion

Two-stage revision is still considered the gold standard in our institution and is reserved for complex cases or for those where the bacterial isolate is unusual or simply not known. Single-stage revision is a viable alternative and can be used judiciously for appropriate patients.

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