Surgical treatments for patients with an infected total knee arthroplasty

Two-stage revision arthroplasty is the most commonly used procedure when a knee replacement becomes infected, but less lengthy and invasive procedures also show evidence of success.

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Total knee arthroplasty is used to treat end-stage arthritis from myriad causes, including osteoarthritis and rheumatoid arthritis. The procedure involves reshaping the distal end of the femur, the proximal tibia, and the undersurface of the patella using an oscillating saw. Bony ends thus prepared are then resurfaced with metal components and either cemented in place or fitted together using a very tight press-fit technique. Finally, a polyethylene insert is placed into the tibial implant as an articular surface for the femoral component (**Figure 1**). Total knee arthroplasty allows patients with severe arthritis to walk with less pain and to improve function and activity levels.

INFECTED TOTAL KNEE ARTHOPLASTY

Total knee arthroplasty carries multiple risks, including the risk of hardware wear or failure, loosening of aseptic hardware, deep vein thrombosis, and infection. Of the small number of arthroplasty failures that do occur, infection is a frequent and costly cause. Hanssen and colleagues documented a 2.5% infection rate for 18,749 total knee arthroplasties performed at the Mayo Clinic between 1969 and 1996.[1] Johnson and Bannister found a superficial infection rate of 4.9% and a deep infection rate of 5.3% after reviewing 471 arthroplasties.[2] In yet another study, 35 infections occurred following 695 primary and 133 revision total knee arthroplasties, resulting in an overall infection rate of 3.6%.[3] Total knee arthroplasty is becoming more common as the population continues to age. The increasing number of these procedures means that the number of infected arthroplasties will increase as well.

Staphylococci are the most common organism associated with both superficial and deep infections. Deep total joint infections are essentially cases of septic arthritis in the presence of metal arthroplasty components. The metallic components act as a nidus for bacteria, making eradication of infection more difficult than in cases of septic arthritis without the metal components. As the infection progresses, it can invade the interface between the host bone and the implant or cement fixing the implant. Such progression of infection can cause the components to loosen, a condition that can be treated only by removing the component. Additionally, infection in the implant-bone interface makes eradication by surgical and pharmacologic means more difficult and may also require component removal—not because the implants have failed but to allow the infection to be eradicated.

Risk factors for infection include rheumatoid arthritis, diabetes mellitus, a history of multiple knee surgeries, and previous infection of the same joint.[2,4-6] Preoperative management of chronic medical problems, including tight glycemic control, adequate nutrition, and smoking cessation, can decrease the risk of postoperative infection.[7] The use of chlorhexidine or iodine showers the night before surgery can also be beneficial.[8] At the time of surgery, additional actions can be taken to decrease the risk of infection. Vince and Abdeen suggest careful incision planning in the instance of multiple previous incisions; using the most recent-

FIGURE 1. Standard total knee arthroplasty

ly healed incision is recommended.[7] Other factors potentially affecting the risk of wound contamination include length of surgery, amount of traffic in the operating room, preparation of the operative site, use of airflow, and dress of the operative team.[1,9]

Signs and symptoms of an infected arthroplasty include joint pain increased beyond normal stiffness and soreness, new onset of decreased range of motion, increased swelling or joint effusion, warmth and erythema about the affected joint, woody edema around the surgical site, and wound drainage.[1,6] Systemic symptoms, although frequently absent, may include fevers, night sweats, and general malaise.

When total joint infection is suspected, early diagnosis and proper treatment increase the chances that the total joint components can be retained. Diagnostic tests should include radiography to look for loosening of the components (**Figure 2**), tests for inflammatory markers such as ESR and C-reactive protein (CRP), WBC count, blood cultures, and sterile aspirations of joint fluid for culture, sensitivities, and cell counts.[10] Aspiration of a newly painful total joint is considered mandatory, even when other signs of infection are absent, to rule out low-grade, smoldering infection.

Joint aspiration is probably the most sensitive diagnostic test. The aspirate should be examined for color and cell count, and the fluid should be cultured. Hannsen and Rand reference a study showing that joint aspiration had a positive predictive value of 75% and a negative predictive value of 94% for diagnosing joint infection.[1] Barrack and colleagues found that fluid aspirations in uninfected knees averaged fewer than 500 WBCs with less than 30% polymorphonuclear leukoctyes.[11] The study also suggested that a 96% positive predictive value for infection was obtained when intra-articular aspirations showed approximately 75% polymorphonuclear leukocytes with 2,000 WBCs.[11]

An abnormality of joint fluid in combination with elevations in WBC count and ESR and CRP levels points to a deep intra-articular infection. The combination of diagnostic modalities assists providers in diagnosing the infected total knee arthroplasty.

THE RANGE OF TREATMENTS

The goal of treatment for an infected total knee arthroplasty is to eradicate the infection, preventing it from spreading locally or systemically, and to leave the patient with a well-functioning, relatively pain-free joint. Methods of achieving this goal include antibiotic suppression therapy and various surgical procedures.

FIGURE 2. Radiographic finding of loosened tibial implant in an infected knee arthroplasty

Antibiotic suppression therapy has a very low success rate: in a study by Johnson and Bannister, for example, 25 deep infections were treated with antibiotic suppression therapy and only two resolved.[2] Nevertheless, this approach is an alternative for patients in whom surgery or anesthesia and associated risks are not feasible or for those who meet certain criteria, including infection with a microorganism of low virulence, infection with a microorganism susceptible to oral antibiotics, ability to tolerate antibiotics without serious complications, and no loosening of the prosthesis.[12]

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KEY POINTS

- Two-stage revision arthroplasty is the most commonly used treatment for infected total knee arthroplasty and has thus far had the best treatment results reported in the literature.
- Alternative treatment options have been employed to attempt to shorten duration of disability, reduce the number of surgeries, reduce costs, and improve ultimate outcome.
- These alternatives include single-stage total knee revision arthroplasty, open irrigation and debridement, and arthroscopic irrigation and debridement.
- The alternative procedures have had some success, and evidence suggests that they may have a role when treating early infections or against certain infecting organisms. Additional research needs to be done, however, to determine their overall effectiveness and appropriateness.

FIGURE 3. Infected total knee arthroplasty with antiobiotic "block" spacer

Surgical intervention is the most common treatment for infected total knee arthroplasty. The options include **two-stage resection arthroplasty**, **one-stage resection and reimplantation**, **irrigation and debridement alone**, and **arthroscopic irrigation and debridement**, all discussed later in this article. **Fusion of the knee joint** and **above-knee amputation** can also be done, although these are clearly considered salvage procedures and are treatments of last resort, usually performed only after other surgical treatments have failed to eradicate the infection or to treat the patient who continues to suffer with either persistent infection or a poorly functioning, painful knee.

The primary decision to be made with a newly diagnosed infected knee arthroplasty is whether the infection can be treated with retention of components or if the components will need to be resected in order to eradicate the infection. When components are resected, reimplantation on a delayed basis (4 weeks to 3 months) occurs after eradication of infection via repeated debridements and prolonged antibiotic therapy.

TWO-STAGE RESECTION ARTHROPLASTY

The most common and reliable treatment approach for an infected arthroplasty is a two-stage procedure that allows infection to be eradicated before the new, revised joint components are inserted.

Stage I After diagnosis of an infected arthroplasty is made, the patient is brought to the operating room for irrigation, debridement, and resection of components. An incision and arthrotomy are performed; and the polyethylene, femoral, tibial, and patellar components are removed, as is any bone cement that may remain in place. When components are removed, care is taken to preserve as much bone stock as possible to allow a foundation for the reimplantation of new components at a later date. The soft tissues are thoroughly debrided, typically removing the synovium and any additional necrotic tissue or bone. The joint is then copiously irrigated using antibiotic solution.

The second part of stage I of the procedure is to place an antibiotic spacer in the joint to maintain the space for reimplantation of the components in the future and possibly to allow the patient to ambulate until component reimplantation can be completed. The spacers are made with bone cement impregnated with antibiotics. This cement allows the antibiotics to elute into the joint and surrounding tissues over time, usually several weeks, to help eradicate infection. The goal of the spacer is to provide patient comfort and mobility, prevent the loss of joint space due to scarring and tightening of tissues, enhance bone quality, and allow for treatment of the infection locally with time-released antibiotics.[13]

Spacers can be simple block-shaped (**Figure 3**) or quasi-functioning articulating (**Figure 4**) devices. Recent studies suggest that using an articulating antibiotic spacer allows for better functioning for patients between the stage I and stage II procedures.[4,14,15] Articulating spacers may be custom made from coating the patient's own sterilized implants with cement at the time of resection or may be constructed from prefabricated cement molds. After the antibiotic spacer is implanted, the incision is closed; and the patient may be allowed to have at least partial weight bearing and range of motion of the joint. The patient is also treated with IV antibiotic therapy, with the choice of antibiotic dependant on microorganism culture and sensitivity results. Courses of antibiotics range from 14 days to 12 weeks.[12,16-18]

Stage II The second stage of the arthroplasty occurs after the infection is eradicated. The length of time between the first-stage and second-stage procedures ranges from 4 to 58 weeks and depends on the patient's medical condition, the physical condition of the joint itself, and results of repeat aspiration/culture and tests for inflammatory markers.[14,16-20] Stage II consists of the removal of the antibiotic spacers and components, repeat debridement, and reimplantation of a revision total knee arthroplasty (**Figure 5**). This procedure is done using the same incision and approach that was used previously. Once the spacers are removed and bony and soft tissues are thoroughly debrided, revision total knee implants are cemented in place using antibiotic bone cement. Following revision arthroplasty, there are generally no restrictions in weight bearing or range of motion.

The two-stage revision procedure is generally considered to be the gold standard treatment for infected total knee arthroplasty. Cuckler reports no recurrence of infection with an average follow-up of 5.4 years for 44 infected total knee arthroplasties treated with two-stage revision using articulating spacers.[18] Additional studies have described success rates that depend on the type of infecting organism. In a study by Hirakawa and colleagues, a success rate of 66.7% was found when high-virulence organisms (*Staphylococcus aureus*,

Enterococcus species, methicillin-resistant *S aureus*) were involved.[16] The success rate was 80% when infection was with low-virulence organisms (*Staphylococcus epidermidis*, streptococci, *Proteus* species) and 71.4% with polymicrobial organisms.[16] Hart and Jones reported that infections were successfully eradicated in 42 of 48 patients (88%) and that of the six patients with persistent infection, four were successfully treated with further two-stage procedures.[19]

In addition to eradication of infection, another goal of revision total knee arthroplasty is to provide the patient with a functional knee that allows for ambulation and freedom to perform everyday activities. Outcomes following two-stage treatment, while not as good as those following primary arthroplasty, are certainly acceptable in many studies. Hospital for Special Surgery knee scores were presented in two studies and showed good to excellent results in 90% and 75.6% of patients respectively.[14,16] Hofmann and colleagues showed an increase in average range of motion from 6 degrees to 91 degrees before revision to 4 degrees to 104 degrees after revision, an increase of 16 degrees in arc of motion.[14] A decrease in the average flexion of 9 degrees, from 92 degrees to 83 degrees, was documented in another study.[16]

ONE-STAGE RESECTION AND REIMPLANTATION

The medical literature suggests that primary exchange revision arthroplasty may be a viable alternative to the two-stage revision procedure. In one-stage surgery, incision and arthrotomy are performed in the usual way; and a thorough irrigation and debridement are done, all infected total knee components are removed, and new total knee components are placed during the same session. In one study, 22 infected total knees were revised using single-stage resection and reimplantation.[21] The patients were then treated with 4 to 6 weeks of IV antibiotics, followed by 6 to 12 months of oral antibiotics under the guidance of an infectious disease consultant.[21] One patient expired as a result of overwhelming sepsis, one patient was lost to follow-up, and one infection recurred 6.5 years later (and was successfully treated with one-stage resection/reimplantation).[21] Nineteen of 21 patients showed no signs of recurrent infection at an average of 10.2 years of follow-up.[21]

IRRIGATION AND DEBRIDEMENT ALONE

In both the one-stage and two-stage procedures, the infected total knee components are removed and replaced with new components. Another surgical alternative is open debridement and irrigation of the infected joint with retention of the primary total knee components. The advantages of component retention include reduced stress for the patient, less bone loss, better function of the knee, and less cost to the health care system. This procedure is not an option, however, if any of the primary components show signs of septic loosening.

The procedure itself involves arthrotomy, obtaining appropriate cultures and Gram's stain specimens, inspecting the components for loosening, and a complete synovectomy and thorough debridement of grossly infected and necrotic tissue. The joint is then copiously irrigated with antibiotic solution. The tibial polyethylene is removed, when possible, to allow for improved exposure and thorough debridement and irrigation of the posterior knee. A new polyethylene liner is inserted and the wound is closed, usually over surgical drains. Patients are placed on IV antibiotics after surgery, and follow-up includes an infectious disease consultant.

Mont and colleagues treated 24 patients with infected total knee arthroplasties who had onset of infection symptoms within 30 days of presentation and no radiographic evidence

FIGURE 4. Articulating antibiotic cement spacer

FIGURE 5. Revision total knee arthroplasty

of loosening.[22] Ten of the 10 knees with infections occurring in the early postoperative phases (less than 3 months following initial joint replacement) were retained; and 10 of the 14 late infections (occurring more than 3 months after primary replacement–presumptively, hematogenously-infected knees) were retained.[22] Another study used open irrigation and debridement to treat 33 patients with acute gram-positive infected total knee arthroplasties with poor success.[5] Of the 31 patients who underwent debridement with component retention, 20 (65%) experienced recurrent infection and eventual removal of components.[5] These studies suggest that both the duration of symptoms and the infecting pathogen must be considered when deciding to proceed with an open irrigation and debridement with retention of the primary total knee components.

ARTHROSCOPIC IRRIGATION AND DEBRIDEMENT

An alternative to open irrigation and debridement is to attempt eradication of infection with arthroscopic surgery and antibiotic therapy. Arthroscopic surgery reduces trauma to the infected joint and soft tissues compared with open surgery. The major drawback of an arthroscopic approach is that the posterior knee cannot be adequately debrided because the polyethylene liner is retained.

With arthroscopic debridement, numerous small portals are made around the infected knee to allow visualization with the arthroscopic camera and to allow for inflow and outflow of antibiotic saline through the joint. Debridement is achieved using a motorized shaver through the various portals. An aggressive, meticulous synovectomy is performed in the various compartments of the knee, including the medial and lateral gutters, anterior knee, suprapatellar pouch, and femoral notch. Again, antibiotic therapy under the guidance of an infectious disease consultant should be instituted postoperatively.

Studies of this approach have had varying results. Five patients with infected total knee arthroplasties and symptoms present for less than 7 days were treated with arthroscopic irrigation and debridement; at an average of 41 months follow-up, none have needed or undergone revision.[23] Other studies have not reported such successful results, however. Waldman and colleagues achieved eradication of infection in 6 of 16 patients treated with arthroscopic irrigation and debridement.[24] Dixon and colleagues reported similar findings, successfully retaining the primary total knee components in 9 of 15 patients using arthroscopic irrigation and debridement.[25] The use of arthroscopic irrigation and debridement is very controversial, and these studies show that while more research needs to be done on this procedure before it is widely practiced, it may be an option for a patient whose health may not permit open revision or debridement.

CONCLUSION

Two-stage revision arthroplasty is the most commonly used treatment for infected total knee arthroplasty and has thus far had the best treatment results reported in the literature. Even with this procedure, however, patients should expect to lose some function of their prosthesis following two-stage revision arthroplasty. Alternative treatment options have had some documented success at eradicating infection, and some evidence suggests that they may have a role when treating early infections or against certain infecting organisms. Additional research needs to be done, however, to determine their overall effectiveness and appropriateness. Two-stage revision arthroplasty is a long, difficult treatment, and with patients living longer with more health problems, a less traumatic alternative for the infected total knee arthroplasty will need to be developed. If these alternative treatments can approach the success rate of two-stage arthroplasty, they will be viable options. JAAPA

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