The management of an infected total knee implant is a major challenge to the orthopedic surgeon. It has been approached in a variety of ways: by use of antibiotics alone or in conjunction with debridement,1–3 resection arthroplasty,1,4,5 arthrodesis,1,3,6,7 or two-stage reimplantation.7–15 A delayed exchange arthroplasty has been favored over an immediate exchange procedure in the hope that the infection could be better controlled prior to reimplantation. One major problem with this technique is that the patient experiences impaired mobility, severe disability and pain in the interval between the resection and the reimplantation. Furthermore, the surgical dissection at the time of reimplantation is often difficult. Some authors mentioned that using antibiotic-impregnated interpositional cement (Ab-PMMA) blocks or beads could avoid the morbidity of the delayed exchange procedure.21–24 Many patients, however, suffered from impaired mobility due to pain and instability. The cement blocks may cause bone erosion due to weight bearing for long periods of time. Furthermore, we observed two cases in our department in which the C-reactive protein (CRP) level did not decrease to normal values until the cement block was removed.

The purpose of this study was to describe our technique of using long leg cylinder casting for immobilization of the knee instead of putting cement blocks or beads within the knee in the interval between stages. This treatment provides better stability and causes less pain for the patient. Surgical dissection in the revision surgery is not difficult.
patients and at this hospital in the remaining patients. Laminar air flow rooms, routine preoperative and postoperative antibiotic therapy were used in all reimplantation procedures performed at this hospital. The clinical data are listed in the Table.

**Diagnosis of infection**

The diagnosis of infection was made clinically, roentgenographically, and on the basis of aspiration cultures. The interval from index arthroplasty to diagnosis of infection ranged from 1 week to 2 years (Table). Clinical signs of infection included a documented effusion in four patients, increased temperature of the knee in five patients, cellulitis in two patients, fever elevation in four patients, and pain in all seven patients. The CRP level was elevated in all patients except for one patient with fungus (*Candida albicans*) infection. Cultures of knee aspirate were obtained in all patients and enabled correct identification of the infecting organisms in six patients. The organisms from aspiration culture included methicillin-resistant *Staphylococcus aureus* (three patients), coagulase negative staphylococcus (two patients), and *Candida albicans* (one patient), with one negative culture. Of the five patients who developed infection less than 1 year after index arthroplasty, four had wound-healing problems. These problems included prolonged wound drainage (longer than 6 days) in one patient, hematoma formation with drainage in one patient, and wound dehiscence in two patients.

**Treatment—first stage**

Initial unsuccessful attempts at infection control consisted of open debridement retaining components in one patient with rheumatoid arthritis. This patient had the longest length of hospital stay, a total of 6 weeks. All patients eventually were treated by debridement of sinus tracts and the synovium, followed by removal of the prosthesis, cement, and cement membrane. The resected bone ends and joint space were irrigated thoroughly with normal saline and aqueous povidone-iodine solution.

The cement membrane and fluid were submitted for aerobic, anaerobic and fungus culture and antibi-otic sensitivity tests. The wound was closed after copious irrigation and two drainage tubes were inserted. No antibiotic-impregnated cement blocks or beads were placed and a long leg cylinder cast was applied for immobilization (Fig.).

Systemic antibiotic therapy was instituted based on the results of cultures collected and sensitivities determined both preoperatively and intraoperatively. Intravenous antibiotics were administered for an average of 4.4 weeks (range, 4 to 6 weeks) and then changed to oral form for an average of 2.1 weeks (range, 2 to 3 weeks) prior to reimplantation. Serial CRP was checked at two-week intervals, and returned to normal values (< 0.8 mg/dL) in all except one patient, with a fungal infection. Antibiotic treatment was discontinued after CRP returned to normal. A rehabilitation program including quadriceps muscle exercise was started on the second postoperative day. After drainage tubes were removed, patients were able to walk with a walker and then discharged from the hospital with an average length of hospital stay of 4.6 weeks (range, 4 to 6 weeks, Table).

**Fig.** Radiographs of knee in anteroposterior and lateral view after removal of the prosthesis with no cement block and with long leg cast.

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Age (yr)/gender</th>
<th>Interval to infection</th>
<th>Organism</th>
<th>Hospital stay / interval to reimplantation</th>
<th>Follow-up period</th>
<th>Follow-up Knee Score</th>
<th>ROM</th>
<th>Last CRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62/M</td>
<td>1.5 years</td>
<td>Staph. coag. neg.</td>
<td>4 weeks/6 weeks</td>
<td>7 years</td>
<td>88</td>
<td>5°–95°</td>
<td>0.73</td>
</tr>
<tr>
<td>2</td>
<td>65/F</td>
<td>1 month</td>
<td>MRSA</td>
<td>4 weeks/6 weeks</td>
<td>6 years</td>
<td>86</td>
<td>5°–105°</td>
<td>0.427</td>
</tr>
<tr>
<td>3</td>
<td>67/F</td>
<td>3 weeks</td>
<td>MRSA</td>
<td>6 weeks/10 weeks</td>
<td>3 years</td>
<td>78</td>
<td>5°–85°</td>
<td>1.68</td>
</tr>
<tr>
<td>4</td>
<td>75/F</td>
<td>3 months</td>
<td>Candida albicans</td>
<td>6 weeks/8 weeks</td>
<td>3 years</td>
<td>91</td>
<td>5°–95°</td>
<td>0.541</td>
</tr>
<tr>
<td>5</td>
<td>70/M</td>
<td>1 week</td>
<td>MRSA</td>
<td>4 weeks/6 weeks</td>
<td>3 years</td>
<td>80</td>
<td>5°–95°</td>
<td>0.259</td>
</tr>
<tr>
<td>6</td>
<td>67/F</td>
<td>9 months</td>
<td>negative</td>
<td>4 weeks/6 weeks</td>
<td>2 years</td>
<td>85</td>
<td>5°–95°</td>
<td>2.16</td>
</tr>
<tr>
<td>7</td>
<td>69/F</td>
<td>2 years</td>
<td>Staph. coag. neg.</td>
<td>4 weeks/6 weeks</td>
<td>1 year</td>
<td>94</td>
<td>5°–105°</td>
<td>0.66</td>
</tr>
</tbody>
</table>

*Case 3 is rheumatoid arthritis, others are osteoarthritis. M = male; F = female; Staph. coag. neg. = Staphylococcus aureus coagulase-negative; MRSA = methicillin-resistant Staphylococcus aureus; HSS = Hospital for Special Surgery; ROM = range of motion; CRP = C-reactive protein.
Reimplantation—second stage
Reimplantation was performed at an average of 6.9 weeks after removal of the implants (range, 6 to 10 weeks). The components were all cemented without antibiotics in all patients. All reimplantations were performed in laminar airflow rooms. No specialized flap construction or skin grafts were required at reimplantation for coverage of the implants.

Postoperatively, intravenous antibiotics were administered for 1 week in six patients, and for 2 weeks in one patient with a fungal infection. CRP and erythrocyte sedimentation rate (ESR) levels were used to monitor intravenous antibiotic administration. All patients were discharged uneventfully and oral antibiotics were administered for 1 further week. The average length of hospital stay was 10 days (range, 9 to 12 days).

Follow-up evaluation
Follow-up evaluation consisted of the Hospital for Special Surgery Knee Score (HSS score), which includes a subjective pain evaluation, assessment of functional performance, and objective measurements of the quadriceps strength, knee stability, and range of motion (ROM). Scores of 85–100 were considered excellent, 70–84 good, 60–69 fair, and scores less than 60 were considered poor. Clinical signs of persistent infection such as swelling, redness, local heat, indurations, and drainage were also noted. Determination of CRP and erythrocyte sedimentation rate was performed. Standing anteroposterior lateral and tangential patellar roentgenograms were also taken.

Results
Follow-up evaluation of seven patients was obtained at an average of 3.5 years (range, 1 to 7 years) after reimplantation. The average HSS score was 86 (range, 78–94) [Table]. These scores indicated excellent results in five patients, and good results in two patients. One of the patients with good knee scores had rheumatoid arthritis with multiple joint involvements. He had only mild to moderate pain in his knee on walking and a range of motion of 5°–85°. The functional loss was secondary to rheumatoid arthritis. The average ROM was 91° (range 80°–100°) [Table].

CRP and ESR were checked in all patients at follow-up evaluation. CRP values ranged from 0.259 to 2.16 (Table) and ESR values ranged from 1 to 20 mm/hour. No recurrent signs and symptoms of infection were found in any of the patients.

Discussion
The patient with an infected total knee implant represents a major challenge to the orthopedic surgeon. The management of infected total knee arthroplasty remains a controversial topic and is likely to remain so, because of the relative rarity of this disorder, the variety of treatment modalities, and the numerous significant variables that affect treatment outcome.

Depending on the specifics of a given case, the following alternative methods of treatment may be appropriate for the infected total knee arthroplasty: antibiotic therapy alone; some form of drainage and debridement retaining the components followed by a course of antibiotic therapy1–3; resection arthroplasty with or without fusion followed by a course of antibiotic therapy1,3–7; debridement with immediate revision (one-stage procedure) of components with or without antibiotic-impregnated cement and followed by a course of antibiotic therapy; initial debridement of all components, cement, and infected tissue with or without the use of an antibiotic spacer followed by a course of antibiotic therapy and early (2 weeks or less) or late (4 weeks or longer) reimplantation with or without antibiotic-impregnated cement (two-stage procedure)7–17; and as a last resort, amputation for life-threatening infections.

Criteria for identifying patients who are potentially good candidates for suppression with antibiotics alone include presence of a low virulence organism, well-fixed prosthesis, and an implant that would be difficult to remove (such as a hinged implant or long cemented stems). Combined results from several series reveal success in only 21% of these patients.

In debridement and prosthesis retention management, timing of the debridement appears to be critical to the success of the technique. Early postoperative infections are more successfully treated with debridement than those that occur by late hematogenous spread. Schoifet and Morrey18 reported results of this management approach in 37 infected total knee replacement (TKR) cases. The overall success rate was extremely poor at 23%. Because of the poor results, the above two alternative methods are no longer used in practice except in special cases, such as when the patient cannot tolerate the surgery or for temporary procedures.

Although definitive resection arthroplasty management usually achieves successful eradication of the infection, it is best reserved for those patients who have minimal ambulatory demands.
Arthrodesis is reserved for young patients who have high functional demands, isolated single-joint disease, extensor mechanism disruption, poor soft-tissue envelope around the knee, and recurrence of the infection after two-stage reimplantation. The ability to obtain a solid fusion is dependent on the type of prior implant that was present, severity of bone deficiency, adequate control of infection and fusion technique.

Amputation is an unfortunate possibility for any patient whose TKR becomes infected. However, this procedure is rarely required because alternative salvage techniques are usually successful. The factors that most commonly lead to amputation include multiple revisions for chronic infection, use of a hinged prosthesis, severe bone loss, intractable pain, and occasionally life-threatening uncontrollable sepsis.

The use of antibiotic-impregnated beads or blocks in two-stage salvage of total knee arthroplasty has been reported in several series. There are several major therapeutic functions associated with antibiotic-impregnated cement blocks in two-stage reimplantation: antibiotic delivery, mechanical stability, and spacer effect. However, antibiotics are released into fluid by a diffusion process. The amount of antibiotic that is released is proportional to the surface area of the cement, the concentration in the cement, the amount of fluid around the cement, and the frequency of the turnover of this fluid. Antibiotic release ceases after a period of time. The cement block remains as a foreign body after the antibiotic concentration declines, and we observed two patients whose CRP level did not decline until the cement block was removed.

Adding antibiotics weakens the mechanical strength of the cement. Some authors used cement to help form the geometry of the knee joint, where the distal femoral condyle and proximal tibia plateau directly contact together. However, this may result in cement debris, a cause of osteolysis. Some doctors autoclave implants after removing them and then place them again immediately. Unfortunately, this may result in loosened interfaces between the prosthetic components and the bony surfaces, and patients may not be able to ambulate due to instability.

Insall et al. reported on two-stage reimplantation without the use of an antibiotic-impregnated spacer at reimplantation with excellent success. In their study, 11 of 11 knees with an average 33-month follow-up showed no recurrent infection. Functional and roentgenographic follow-up results were reported as fair to excellent. The length of hospital stay for these patients, however, averaged 12 weeks. In our study, after an average hospital stay of 4.6 weeks, patients could be discharged with long leg cast and walk with a walker-aid. The stability provided by the long leg cast appears to be sufficient for patients and is also an important factor for infection control. Wound care can be carried out through windowing the cast.

Soft tissue contracture worsens with the increased time delay. In this study, no antibiotic-impregnated cement spacers were inserted and the appropriate use of intravenous antibiotics according to the sensitivity test led to shortened time between stages. The average interval to reimplantation in our study was 6.9 weeks. Although the use of a spacer might reduce the possibility of soft tissue contracture, it was not a problem in these patients for surgical dissection during reimplantation arthroplasty.

Finally, many infectious total joint arthroplasties occur after dental procedures. Patients should be well educated about this issue and the need for antibiotic prophylaxis before any dental procedure.

Conclusions

Several studies have indicated that two-stage exchange with antibiotic-impregnated cement spacers and prosthesis fixation is an effective technique for reimplantation. This report documents our successful use of a modified method without antibiotic-impregnated cement in 7 cases of TKR. The method has many advantages such as good knee stability, less knee pain, shorter time for revision and shorter length of hospital stay, less cost and less soft tissue contracture. It is more tolerable for the patients and simpler for the surgeons and, most importantly, results in a low likelihood of recurrence.

References


