Management of infected total knee replacement

Vineet Sharma MS*, Amar S Ranawat MD**, CS Ranawat MD**

*Advanced Hip and Knee Clinic, **Ranawat Orthopaedics Center

ABSTRACT

Infection after a total knee replacement is an uncommon but disastrous complication. The diagnosis and treatment of an infected total knee has become quite standardized over the last few years. With an increasing number of total knee replacements being performed, the absolute number of patients with this complication is going to increase over time. The article presents an overview of the extent of problems, the predisposing factors, classification and diagnosis and treatment guidelines. With two-stage reimplantation emerging as the gold standard for treatment of infected total knees, the method is described in detail along with the various types of spacer options available and the long-term results.

Keywords: Infected knee replacement, two stage reimplantation, articulating spacer.

Infection is a disastrous complication after Total knee replacement (TKR). The reported incidence in literature varies between 0.3-12.4% for primary TKR and between 1-15% for revision TKR1-8. Fortunately, the treatment of peri-prosthetic knee infection has become very standardized and outcome more predictable over the last decade. Around one third of infections occur in the 1st three months after surgery and the other two-third after 3 months. Various factors contribute to the pathogenesis of infection after TKR.

Table 1

<table>
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<th>Risk factors for infection after TKR9-18</th>
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<td>1. Host Factors</td>
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<td>b. Diabetes</td>
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<td>c. Rheumatoid arthritis</td>
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<td>d. Urinary tract infection</td>
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<td>e. Kidney or liver transplant</td>
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<td>g. Steroid intake</td>
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<td>h. HIV infection</td>
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<td>i. Malignancy</td>
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<td>j. Obesity</td>
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<td>k. Revision surgery</td>
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<td>1. Intraoperative factors</td>
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<td>a. Surgical time &gt; 2.5 hours</td>
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<td>b. Operation theatre environment</td>
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<td>c. Human traffic in theatre</td>
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One of the most important factors to prevent infection after TKR is administration of pre-operative antibiotic within 30-45 minutes of skin incision19,20. Surgical closure of the wound especially at the lower third of incision close to the patellar tendon is very important. Most patients who develop infection later start with serous discharge from the lower part of the wound in early post-op period (Fig. 1).

Routine use of antibiotic impregnated cement has been shown to reduce the incidence of infection in the Norwegian joint registry but indiscriminate usage in all cases needs to be weighed against potential development of resistant organisms21-24.

Fig. 1. Patient with draining wound at the lower end of incision.

A few factors of doubtful efficacy in prevention of infection are the use of laminar airflow, body exhaust suits and hoods. There is conflicting data on the effect of these factors on the incidence of infection25-27.
**DIAGNOSIS**

Early diagnosis of deep infection is imperative to salvage the prosthesis with debridement and retention, otherwise prosthesis removal is required. Diagnosing an infected TKR can in some cases be quite challenging. Most infected knees present with pain. The chronology of pain and its association is important. Also the onset of pain after surgery helps in deciding between early and delayed infection. A review of the post-op notes regarding delayed wound healing and serous discharge from wound beyond 48 hours is also important. Plain radiographs are most often normal but in late stages with chronic infection, sequential X-rays may show progressive radiolucencies, focal osteopenia or osteolysis of subchondral bone and periosteal new bone formation. Imaging studies, like the indium-labeled scans are non-specific and rarely indicated for diagnosis.<sup>30,31</sup>

The gold standard for diagnosis is the triple test. Knee joint aspiration, ESR and CRP are done routinely in all suspected cases of infected TKR. An abnormal finding in 2 out of these 3 is quite suspicious for infection. Knee joint aspiration should be done with patient off antibiotics for atleast 7-10 days otherwise false-negative results are common. Knowledge of the return of ESR and CRP to normal after surgery is quite helpful. CRP usually returns to normal within 3 weeks of surgery and ESR can take up to 3-6 months to come back to normal.<sup>33</sup> Serial trend in these lab tests over a period of time is more helpful than a single raised value.

**CLASSIFICATION**

Classification of peri-prosthetic infection is done in relation to onset of symptoms following the index surgical procedure. In the latest classification system, infection occurring in the immediate post-operative period (4-6 weeks after surgery) is classified as type 2 infection. These patients usually present with wound drainage or cellulites around wound edges along with pain. Patients will usually have a history of prolonged wound drainage, prolonged antibiotic usage etc. The etiology in these cases is mostly colonization at the time of surgery, infected hematomas or spread of superficial infection.

Type 3 infections also occur due to colonization at the time of surgery. But either the inoculum is small or the organism is of low virulence, and thus these patients present with chronic symptoms. Gradually worsening pain or stiffness and deterioration in function slowly over a period of time is the usual presentation. There are usually no systemic or local signs and a high index of suspicion is needed for diagnosis. These infections are often the most difficult to diagnose and the delay in most cases, makes prosthesis retention impossible.

Type 4 infections occur from hematogenous spread of bacteria in a previously asymptomatic and well functioning prosthesis. The common primary sites of infection are urinary tract, dental infections and pneumonia. IV drug abusers and immunocompromised patients are also pre-disposed to these infections.

The latest addition to this classification is type 1 infection. These patients present with a positive intra-operative culture or frozen section at the time of revision for aseptic reasons. At least 2 of the 5 cultures have to be positive for a diagnosis to be made. Treatment in these cases is decided taking into consideration the pre-operative clinical picture and lab. results and the overall clinical picture.

**MANAGEMENT OF INFECTED TKR.**

**Type 2 and 4 infections**

Most acute infections, either in the early post-operative period or late hematogenous infections can be managed with prosthesis retention. The time from onset of symptoms to the initiation of treatment is important. There is a much higher likelihood of prosthesis retention in the 1st week of onset on infection and the chances decrease over time. The chances of eradication of infection are much higher with a sensitive gram-positive organism than with a gram negative bacteria or fungal infection.

These patients are best managed with open debridement, synovectomy and polyethylene exchange. It is recommended to change the polyethylene spacer in all cases. This enables a more thorough synovectomy especially from the posterior capsule and also cleans the interface between the tibial base plate and the polyethylene liner. In case of all-poly tibial design, it is recommended to change the polyethylene tibial component. Results of debridement without poly exchange are far inferior to when the polyethylene is changed. Surgeon should be prepared to increase the thickness of polyethylene by 1 size in many cases. This is due to the fact that after synovectomy, the knee may not be as stable with the same size of polyethylene.

These patients are given IV antibiotics for 2-4 weeks after surgery and followed by oral antibiotics for another 4 weeks depending on the organism and sensitivity. ESR and CRP are monitored weekly at first and then at monthly interval till they return to normal.

If infection recurs even after debridement, polyethylene exchange and prolonged antibiotics, removal of prosthesis and
2-stage reimplantation should be considered.

**Chronic infection**

The Gold standard for chronic infection in TKR is 2-stage reimplantation. One stage reimplantation is more or less out of favor by most surgeons and has limited indications.

**Description of surgical technique for 2-stage reimplantation.**

**Stage 1: Removal of old prosthesis, synovectomy and insertion of antibiotic cement spacer**

After a diagnosis has been made, the 1st step is the removal of old prosthesis, synovectomy and debridement and insertion of an antibiotic cement spacer. The old prosthesis is removed with special effort made to prevent further bone loss. The ease of removal will depend on how long the infection has been present. Not uncommonly, the prosthesis is very well fixed to bone and removal can be quite challenging. The various techniques described for removal of prosthesis include the use of reciprocating saw; giggle saw and stacked osteotome technique. All residual cement is also removed.

A thorough synovectomy is performed next and all infected soft tissue is removed. Care should be taken to prevent iatrogenic damage to the collaterals and patellar tendon. Once a thorough debridement has been performed, an antibiotic cement spacer is inserted.

The various types of spacers are described below.

**Articulating spacers**

These spacers are molded in the shape of distal femur and proximal tibia like knee prosthesis. These spacers allow the knee to be flexed to a certain degree. This allows the soft tissues to be supple at revision surgery and the exposure is easy compared to a static spacer. Also the final ROM with the use of these spacers is better than with static spacers. The articulating spacer can be of several types. The most commonly used techniques are described here.

**Hoffmann Technique**

In this method, after standard exposure and removal of infected prosthesis, the removed femoral prosthesis is autoclaved again. A new all polyethylene tibial component is opened. Patella polyethylene button is removed. After synovectomy, the components are cemented in place. The cementing technique is quite different here as the aim is not to achieve a good fixation but to have just enough fixation to enable the prosthesis to be fixed to bone. Also it should be possible to remove the prosthesis at 2nd stage with minimal bone loss. Excess cement at the side of prostheses is not removed. As the cement is setting, the components are gently toggled to prevent rigid fixation.

**Molded cement spacers**

The spacer can also be made with commercially available cement moulds like the prostalac. These moulds are available in various sizes and need to be determined after removal of prosthesis. Cement mixed with antibiotic is injected into moulds and allowed to harden. Once the cement is set, the moulds are cut with a knife and spacers inserted into the knee (Fig. 2 & 3). These molds add to the cost of the procedure.

**Static cement spacer**

This technique is still the gold standard for cement spacers and is extremely helpful in cases of severe bone loss. The cement mixed with antibiotic is put into the knee in extension.
Fig. 4 a & b- Static cement spacer in a patient with severe bone loss.

In cases of incompetent collaterals, a DCP plate or a Steinmann pin can be put into the medullary canals embedded in the cement. This technique requires the knee to be in extension and in a brace post-operatively. Some authors believe that the use of these spacers provide adequate rest to infected and inflamed soft tissues and thus better eradication of infection (Fig. 4 a & b). But the results with either technique are comparable as far as eradication of infection is concerned.

After the spacer is inserted, the wound is closed. We recommend using non-braided sutures like PDS for closure and avoid using vicryl or ethibond in infected cases. Also usage of drain is avoided after 1st stage, as the elution of antibiotic is maximum within the 1st 48-72 hours after spacer.

Antibiotics in cement spacer

There are lots of recommendations on the nature and amount of antibiotic for cement spacers. Most authors recommend a combination of Vancomycin and Tobramycin in all cases. These have a broad-spectrum coverage and resistance to these antibiotics is not a clinically significant problem at this time. The dosage as recommended by the surgeons at Mayo Clinic is gaining widespread acceptance now (personal communication). They recommend 2-4 gm of Vancomycin and 2 gm of Tobramycin with each batch of cement. Such high dose has not been associated with any systemic side effects on the kidney.

Results of cement spacers

All the 3 techniques mentioned above have an equivalent success rate of over 90%. The articulating spacers have a slightly lower incidence of requiring a special exposure technique at 2nd sage stage of revision including the quadiceps snip and quadiceps turndown (V-Y Plasty). Also the final ROM with use of articulating spacer is slightly better.

Period between 2 stages

The length of this period can vary from 8-16 weeks and is individualized. In the early post-operative, period patient’s knee is kept in extension to allow soft tissue and wound healing. Intra-venous antibiotics are given for 6 weeks. Initially, Vancomycin is given till the culture results are available and then organism-specific antibiotics are administered. It is recommended to get a central line inserted to allow for long-term intravenous antibiotic administration.

Patient is allowed to walk with a walker. Weight bearing varies with the type of spacer inserted. With Hoffmann type of spacer, patient can weight bear as tolerated and with the static and articulating cement mould space, only toe-touch weight bearing is allowed. With the articulating spacer, patient is allowed and encouraged to do bedside range of motion exercises. Flexion should be increased gradually and allowed up to 90 degrees only. Breakage of cement spacer as well as subluxation/dislocation is known complications (Fig. 5 & 6).

Weekly ESR and CRP are done for 6 weeks. IV antibiotics are stopped after 6 weeks. Patient is kept off antibiotics for 2 weeks and a repeat ESR and CRP is done. Once the
values are showing a downward trend and are in the normal range. Planning is done for the 2nd stage. Some surgeons recommend doing a knee aspiration and culture also at this stage.

2nd stage of revision TKR

The knee is exposed in a standard fashion. Surgeon should be familiar with and be prepared to use the special techniques for exposure. These include the rectus snip, quadriceps turn-down (V-Y Plasty), skeletonisation of distal femur and in extremely rare instances, tibial tubercle osteotomy (TTO).

The cement spacer is taken out. Technique for removal will vary with the type of cement spacer in place. With a Hoffmann type of spacer, removal is best done with a reciprocating saw working at the implant-cement interface. Removal of a static spacer can be challenging at times and it is not easy to distinguish the cement from the native bone. For this reason, methylene blue can be added to the cement spacer at 1st stage and this makes the distinction between cement and native bone easier.

Some authors recommend sending frozen section of tissues at 2nd stage to make sure that the infection is eradicated. A cell count of more than 5 neutrophils / HPF is quite suspicious of infection. This technique depends a lot on the experience and expertise of the pathologist. We do not recommend doing this in most cases as this can confuse the picture and we depend solely on the intra-operative clinical picture.

The insertion of revision prosthesis is done paying special attention to joint line, equal flexion and extension gaps and soft tissue balancing. As in most revisions, stems are used for added stability, fixation and alignment. We almost always used hybrid cement fixation in infected TKR’s. This technique involves cementing the prosthesis and the proximal part of stem and press fitting the distal part of stem. This allows for antibiotic cement to elude the antibiotics and also in case of further revision for any reason, removal of stems and cement is relatively easier. We routinely replace the patella in cases of all primary and revision TKR’s. In case of revision, if the patellar bone stock is not adequate, trabecular metal patella can be used. The closure is done in a standard fashion with or without the use of drain as per surgeon preference. We do not use drain in most primary and revision cases (Illustrative case, Figs. 7-14).

Post-operative protocol is similar to primary cases. After the 2nd stage, IV antibiotics are given for 24-48 hours only.
OTHER TREATMENT OPTIONS

Antibiotic Suppression

Antibiotic treatment alone is almost never successful in eradicating deep peri-prosthetic infection and is strongly discouraged. It has a high failure rate and only complicates definitive management. The criterion for using this suppressive therapy are 1) Prosthesis removal is not feasible (medically unfit patient) 2) Microorganism has low virulence, 3) The organism is susceptible to an oral antibiotic, 4) The antibiotic can be tolerated without serious toxicity, 5) The prosthesis is not loose. In these cases, antibiotic can help suppress the infection but development of resistant organisms over time will make this option non-viable. The presence of other joint arthroplasty and cardiac valvular prosthesis is a strong contraindication for use of chronic antibiotic suppression.

Debridement with prosthesis retention

Open debridement may be indicated for an acute infection in early post-op period (Type 2 infection) and for acute hematogenous infection (type 3) of a securely fixed and functional prosthesis. This method is more likely to be successful if 1) less than 2 weeks since the onset of symptoms of infection, 2) susceptible gram positive organism, 3) absence of prolonged post-op drainage or a draining sinus tract, 4) no prosthetic loosening or radiographic signs of infection. The success rate with this technique is very variable and depends on the timing of drainage, duration of symptoms, host immune status and the nature of the microbe. Reported success rate is between 19% to 100%.

Arthroscopic lavage

This has a high failure rate as reported in literature with a few sporadic case reports showing good results. The reasons for poor results with this technique that are inadequate debridement and synovectomy and also the inability to change the polyethylene liner. Also the interface between the tibial base plate and polyethylene cannot be cleaned. The reported success rate with this technique is around 20% to 38%. The only indication might be in patient with fulminant sepsis and who is on DVT prophylaxis, making open surgery difficult. This technique is only of an academic interest now and not recommended in most cases.

Resection arthroplasty

This technique might be used in patients with limited ambulatory needs and who had multiple prior attempts at eradication of infection. Patients with poor bone quality in whom arthrodesis might not be successful are also candidates for resection arthroplasty. Polyarticular RA patients with limited functional demands and in whom eradication of infection is likely to be very difficult are also candidates (Fig. 15 & 16). The functional outcome after resection arthroplasty is poor but patients are able to sit better than patients with arthrodesis. Weight bearing and ambulation are usually difficult due to instability.

Arthrodesis

This is indicated in cases of poor bone stock, poor soft tissue coverage and after failed 2 stage reimplantation. Indications include 1) Individuals with high functional demands, 2) single joint disease, 3) young age, 4) disruption of extensor mechanism, 5) abdominal surgery.
5) poor soft tissue envelope around the knee, 6) systemic immunocompromise. Contraindications include 1) Bilateral knee disease, 2) ipsilateral hip or ankle disease, 3) severe segmental bone loss, 4) contralateral extremity amputation.

The best device to achieve arthrodesis after a failed TKR is an intra-medullary device with a fusion rate between 67% to 100%. With the availability of newer nails, like the Wichita nail, the surgery is quite simple and high fusion rate can be achieved (Figs. 17 & 18). Plate fixation and external fixation devices have a relatively lower success rate in these cases (Figs. 19 & 20). Fusion rate can be as high as 90% after surface replacements and good bone stock and as low as 50% for infected hinged knee replacements.

**REFERENCES**


**AMPUTATION**

Very rarely, if all other techniques fail, an above knee amputation is the last resort to manage an infected TKR. Patients with failed attempts at arthrodesis, lives threatening systemic sepsis, poor soft tissue coverage are a few examples where amputation might be considered. The functional outcome after an above knee amputation in these patients is generally sub-optimal as many of these patients are never fitted with prostheses.


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*Pb Journal of Orthopaedics Vol-XI, No.1, 2009*


