A 'two-staged retention coverage reconstruction protocol' for early exposed septic knee prosthesis with patellar ligament disruption

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Received 05 May 2012
Accepted 20 May 2012

Egyptian Orthopedic Journal 2014, 49:128–133

Background
The worst scenario in total knee arthroplasty is early wound breakdown causing prosthesis exposure and necrosis of the patellar ligament. We describe a new protocol for the salvage of early exposed septic knee prosthesis with patellar ligament disruption.

Patients and methods
Between October 2001 and August 2010, 15 patients (15 knees) presenting with early infected, exposed knee prosthesis with patellar ligament disruption were treated using this new protocol. Strict criteria were used for patient selection suitable for this plan of treatment. Patients had to have presented within 30 days of the index arthroplasty. In addition, no radiographic signs of osteitis or loose prosthetic component were present. In the first stage, thorough debridement accompanied by polyethylene insert removal was performed, along with intraprosthetic antibiotics-impregnated cement spacer insertion. This was followed by a 1-week parentral antibiotic regimen. On the eighth day, a second-stage procedure was performed with spacer removal and new polyethylene insertion, accompanied by medial gastrocnemius flap transposition for prosthesis coverage and patellar ligament reconstruction.

Results
At the latest follow-up (55.2 months), 13 knees (86.6%) have been retained; Knee Society knee and functional scores in these averaged 79.6 and 74 points, respectively, and these patients had regained sufficient extensor mechanism function to return to ambulation.

Conclusion
We recommend this protocol for the management of early exposed infected knee prosthesis with patellar ligament disruption.

Level of evidence
Level IV.

Keywords:
cement spacer, exposed total knee arthroplasty, extensor mechanism rupture, medial gastrocnemius flap, septic knee prosthesis

Egypt Orthop J 49:128–133

1110-1148

Introduction

A successful result after total knee arthroplasty (TKA) abolishes pain, restores the ability to walk, and decreases the need for daily assistance of the patients. However, the worst scenario in TKA is early wound breakdown causing prosthesis exposure and necrosis of the patellar ligament. The super added deep infection further complicates the scenario and often makes patient management a huge challenge.

Thus, it is important to deal with these problems in a timely manner to allow for retention of the prosthesis concomitant with soft-tissue reconstruction to avoid implant replacement, arthrodesis, and amputation [1,2].

Debridement and exchange of the polyethylene insert with retention of the prosthesis represents an attractive surgical modality because of its simplicity, affordability, and low morbidity. Unfortunately, the outcome of this procedure in several other reports has generally been poor, with an overall recurrence rate of 70% [3–5].

Antibiotic suppression and continuous irrigation has been used as an adjunct treatment following these procedures, but the disadvantages of this procedure are the large amount of bleeding in the perioperative period, the possibility of contamination at the time of changing solutions, as well as the necessity of staying in bed during the treatment [6].

Building on the retention concept, the author modified the protocol for the treatment of early postoperative type II infected [7] and exposed prosthesis with patellar ligament disruption into a two-staged one. In the first stage, thorough debridement and irrigation is performed along with polyethylene insert removal. This is accompanied by intraprosthetic antibiotics-loaded cement spacer insertion, followed by a 1-week parentral antibiotic regimen. Thereafter, a second stage

begins on the eighth day with spacer removal and new polyethylene insertion concomitant with medial gastrocnemius flap transposition [8,9] for the prosthesis coverage and patellar ligament reconstruction.

The aim of this prospective study was to examine our experience and results using this new two-staged retention coverage reconstruction protocol for early exposed septic knee prosthesis with patellar ligament disruption.

Patients and methods

From October 2001 to August 2010, 15 patients (15 knees) presented to our university hospital with early infected, exposed knee prosthesis and patellar ligament disruption; they had undergone primary TKA elsewhere.

All patients were treated by the author's staged prosthesis retention coverage reconstruction protocol. The specific indications for this procedure were onset of infection or symptoms within 30 days of presentation (range 5–26 days) with no radiographic evidence of osteitis or component loosening [7].

The 15 patients included nine women and six men, mean age 57.4 years (range 38–73 years). The original diagnosis was rheumatoid arthritis in eight knees, osteoarthritis in five knees, and post-traumatic arthritis in two knees. The skin defect size ranged from 5 × 8 to 9 × 12 cm, with an average of 66.4 cm^2. Relevant patient factors included the use of corticosteroid medication in eight, diabetes mellitus in four, advanced age (>70 years) in two, and tobacco use in one. Local wound factors included multiple scars in one patient and post-traumatic dystrophic skin in another.

Operative procedures

Every patient underwent a short two-stage protocol. The first stage involved knee exposure along the previous surgical scar, and consisted of extensive synovectomy and thorough debridement. Debridement of the posterior region was performed after the removal of the polyethylene insert. Before irrigation, six culture specimens (three for standard culture and three for extended culture) were obtained.

The prosthetic components were checked for loosening. In no instance was there intraoperative evidence of component loosening. The surgical field was then irrigated with 9 l of sterile normal saline (three bags of 3 l volume) using pulsatile lavage.

Antibiotics-loaded bone cement was prepared using a combination of heat-stable antibiotics in powder form. Forty grams of bone cement was mixed with 3.6 g tobramycin and 2 g each of vancomycin, amikacin, and cefotaxime. The polymethylmethacrylate monomer and powder were first mixed together to form the liquid cement, and then the prepared antibiotics powder mixture was added [10].

A custom spacer was molded intraoperatively from a plastic trial tibia insert using the aforementioned bone cement. The articular surface of the trial insert was coated with a sterile lubricant and the moderately doughy bone cement was applied to it. The mold was used to create a custom component with surface contours similar to the original polyethylene component (Fig. 1).

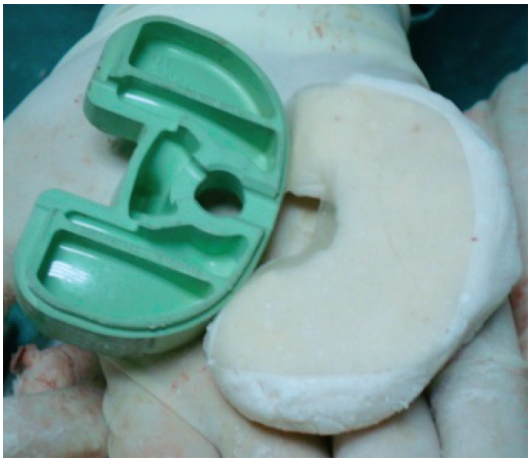
As the cement reached the final polymerization process, the spacer was placed on the prosthesis tibial tray. Bonding of the cement spacer and the underlying tibial tray was prevented by taking the cement construct out a few times before complete setting of the bone cement.

The thickness of the tibial spacer was reduced to 50–80% of the original polyethylene insert thickness to allow for soft-tissue approximation and closure without much tension. No drains were placed and a posterior slab was applied for 7 days postoperatively to prevent knee flexion.

All of the patients were followed up by an infectious disease control specialist. Empirical antimicrobial therapy was commenced for the first 3 days and then maintained on the basis of the results of standard intraoperative cultures.

At the second stage of the protocol (eighth postoperative day), another extensive debridement

Figure 1



Molding the antibiotics-loaded cement spacer matching with the trial insert.

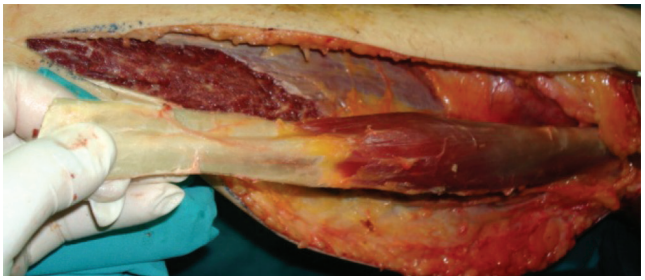
was performed. Tissue specimens were obtained for culture and frozen section. The decision to proceed with spacer exchange with a new polyethylene tibial insert was made on the basis of the patient response to systemic antibiotic therapy, the gross appearance of the wound intraoperatively, and the frozen section results (<25 polymorphonuclear white cells per high-power field). None showed acute inflammation; therefore, all spacers were exchanged with new polyethylene tibial components at the second stage as planned.

A medial gastrocnemius muscle flap was then used in all patients to reconstruct the extensor mechanism and cover the exposed prosthesis using the techniques of Gerwin *et al*. [8] and Jaureguito *et al.* [9], with modification. A separate posteromedial incision parallel to the anterior border of the medial gastrocnemius was performed. The medial gastrocnemius was divided ~5 cm distal to its insertion into the Achilles tendon (Fig. 2).

Proximally, the median raphe was identified between the bellies of the medial and lateral gastrocnemius muscles. Using blunt and sharp dissection, the medial gastrocnemius was divided into its proximal tendon and was freed from its origin to provide an adequate arc of rotation. The medial sural artery was exposed and preserved (Fig. 3).

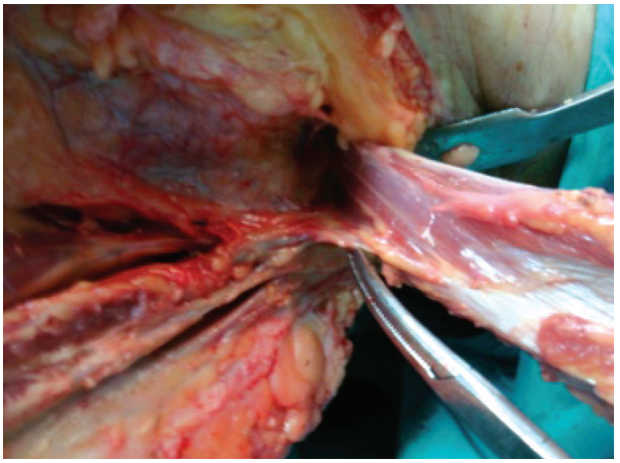
With the knee in full extension, the muscle flap was transposed anteriorly under a medial skin bridge at the level of the knee between the quadriceps tendon and the anterior leg muscles to cover the tibial tubercle, prosthesis, and to reconstruct the extensor mechanism. The upper edge (medial border) of the gastrocnemius flap was sutured to the patellar ligament stump and covered the reconstructed tendon completely, whereas the lower edge (lateral border) of the flap was sutured to the tibialis anterior muscle to reconstruct a continuous extensor mechanism (Fig. 4). In addition, the flap was sutured to all of the tendons around the knee, namely, the iliotibial tract laterally and the pes anserinus medially. Moreover, scoring the fascia over the muscle allowed the muscle to gain length and width in the 9 × 12 cm defect. A split-thickness skin graft was then used to cover the medial gastrocnemius flap and the donor site was closed primarily.

Figure 2



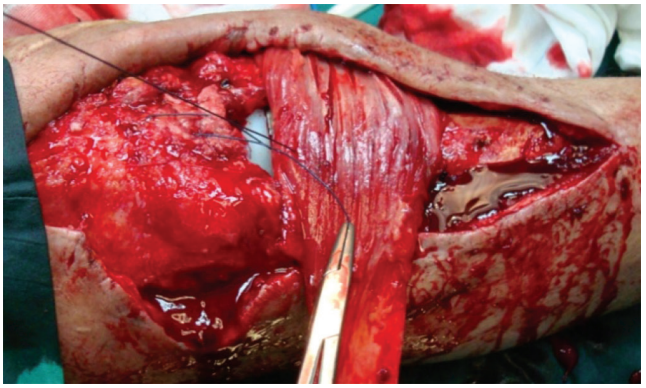
The medial gastrocnemius muscle and attached tendon dissected out from the leg.

Figure 3



The medial sural artery exposed and preserved.

Figure 4



Gastrocnemius muscle flap has been transposed anteriorly at the level of the knee joint to cover the tibial tubercle. The patellar ligament stump is then sutured to the medial border of the gastrocnemius flap.

Aftercare

After flap coverage, the knee was immobilized in extension with a posterior slab and the entire extremity was elevated. The average time for patient discharge was 7–10 days following the last surgical procedure, guided by proper wound condition.

The patient received organism-specific parentral antibiotics for 6 weeks after the operation in accordance with the standard and extended intraoperative cultures. The ESR and C-reactive protein were used to monitor the response to infection.

After complete skin healing was achieved, usually within 2–3 weeks, a new cast was applied and the patient was

allowed progressive weight bearing as tolerated. At 6 weeks, the cast was removed and active extension exercises were commenced by means of straight-leg raising. Gentle, passive ranges of motion exercises were then started. Eight weeks postoperatively, the patients progressed to active range of motion and strengthening exercises. Intensive strengthening exercises were started 12 weeks postoperatively. The patient was placed in a hinged, full-length brace for 8 weeks after the removal of the cast, with progressive flexion dialed into the brace.

The patients were evaluated by two independent consultants. The evaluation included a comparison of the preoperative and postoperative knee and functional scores of the Knee Society [11,12]. The preoperative and postoperative ranges of motion and extensor lag were measured using a hand-held goniometer. Patellar height was measured by the Insall–Salvati ratio (ISR) [13].

Successful prosthetic outcome was based on preservation of function of the knee implant. Arthrodesis, two-stage reimplantation, persistence of infection, or amputation were considered prosthetic treatment failures. Successful flap outcome was based on full flap survival, complete wound healing, and limb preservation. Total flap loss, requiring full debridement and other means of coverage, was considered a failure.

Results

The average duration of the follow-up was 55.2 months (range, 26–106 months). The infecting organism was confirmed by at least three intraoperative culture results in all cases and included *Staphylococcus aureus* (eight knees), coagulase-negative *Staphylococci* spp. (four knees), and *Escherichia coli* (three knees). There were no polymicrobial infections. Preoperatively, the Knee Society knee and functional scores averaged 10.7 points (range, 5–20) and the patellar heights were grossly alta.

Till the date of the last follow-up, 13 knees out of 15 (86.6%) were retained. Their C-reactive protein and ESR returned to normal within 2 months after the second stage (range, 2–4 months). The staged protocol resulted in stable soft-tissue coverage, patellar ligament reconstruction, and eradication of infection (Fig. 5).

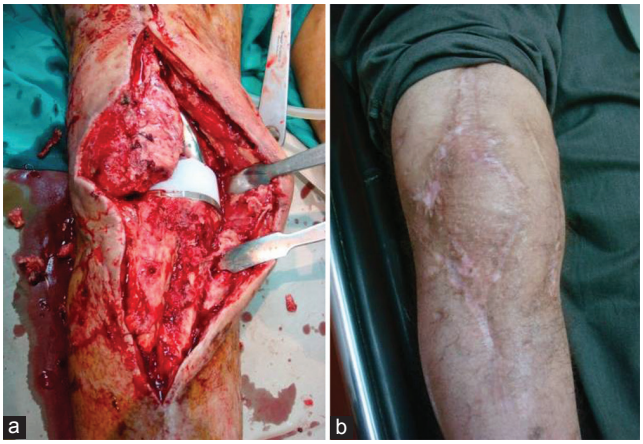
The average Knee Society knee and functional scores of the retained knees were 79.6 (range, 65–98) and 74 (range, 60–90) points, respectively, and all maintained at least a 90° range of active motion. Moreover, these 13 patients regained sufficient extensor mechanism function to return to ambulation. Their average postoperative knee extension lag (Fig. 6) was 10.8° (range, 0–40°).

None of these retained knees had any evidence of osteitis or component loosening at the latest radiographic follow-up evaluation. ISR was normal in seven knees ($0.8 \leq ISR \leq 1.5$) (Fig. 7), and in six knees, ISR showed patella alta (ISR range, 1.6–2.5) (Fig. 8). Two knees in two patients (13.3%) showed recurrence of the infection at 3 and 5 months postoperatively and required two-staged revision surgery. Thus, these were considered failures of the protocol. However, their respective medial gastrocnemius muscle flap survived and covered the revised prosthesis.

Discussion

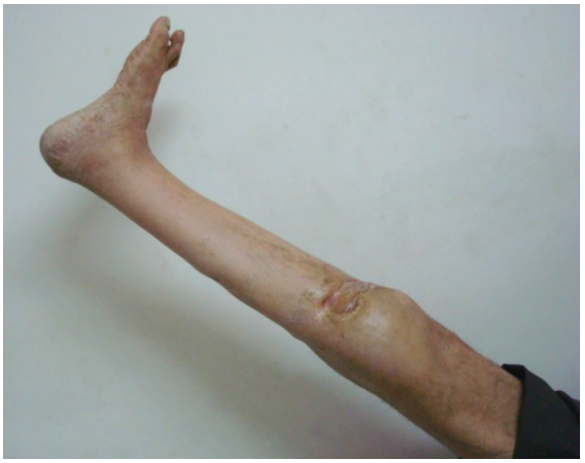
Early infection subsequent to TKA causing tissue breakdown with exposure of the prosthesis along with

Figure 5



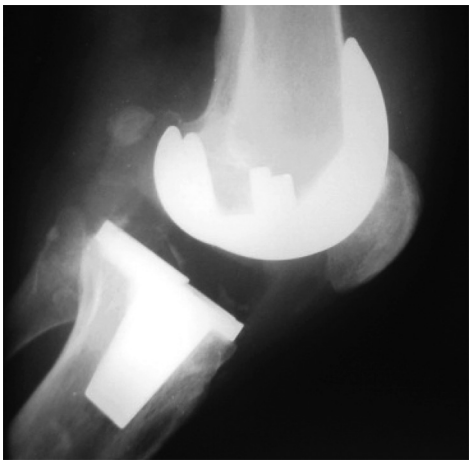
(a) Skin defect at debridement (b) Stable soft-tissue coverage 4 years postoperatively.

Figure 6



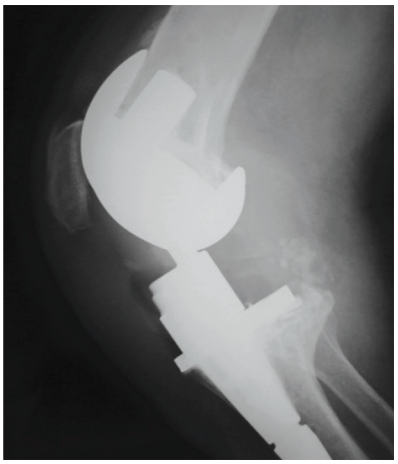
The patient is able to fully extend the knee without presenting any extensor lag.

Figure 7



Normal Insall–Salvati ratio on the lateral radiograph of the retained knee.

Figure 8



Patella alta on the lateral radiograph of the retained knee.

disruption of the patellar ligament is a devastating complication in terms of patient morbidity and institutional expenses. The gold standard of treatment focuses on removing the prosthesis, implanting an antibiotic-impregnated cement spacer, muscle flap coverage, and delayed revision TKA [14].

Retaining the implant after debridement may be a reasonable treatment strategy for prosthetic joint infection in patients with a well-fixed prosthesis. In contrast, only debridement and retention carries a high failure rate [3–5].

To the best of our knowledge, we are the first to report on a two-staged retention coverage reconstruction protocol for early exposed septic knee prosthesis with patellar ligament disruption.

Our treatment protocol offered several advantages. The extensive debridement with a large quantity of saline irrigation in the first stage could be repeated in the second stage to confirm eradication of infection. The temporary spacer formed with the use of antibiotic-loaded cement offered not only a more effective delivery of high antibiotics doses at the site of periprosthetic infection but also prevented reimplantation, improved function, decreased pain, increased patient satisfaction, and decreased cost. The medial gastrocnemius muscle flap provided a vascularized muscle bed, which allowed healing of the reconstructed patellar ligament. There was excellent soft-tissue coverage of the proximal tibial aspect and of the TKA components. Scoring the fascia over the muscle allowed the flap to gain length and width that covered skin defects up to 9 × 12 cm. Consequently, this muscle flap has shown versatility and durability; even so, it may be an inferior construct biomechanically.

Our flap technique does not rely on the bone quality of the patella or the proximal aspect of the tibia; rather, it relies on soft-tissue healing, and therefore, late failure is unlikely. The extensile approach and the rotation of the medial gastrocnemius flap can be performed easily. Finally, there is mild functional donor-site morbidity after the transfer because the soleus and the remaining lateral head of the gastrocnemius function synergistically to provide plantar flexion of the ankle [15,16].

In the current series, the prosthesis was successfully retained in 13 knees. All showed a marked improvement in the Knee Society knee and functional scores. Moreover, in these knees, the infection was considered clinically and radiologically healed.

We agree with a few reports that certain factors must be taken into consideration before attempted retention to achieve successful outcomes. These include

(a) duration of infection less than 30 days,
(b) well-fixed components, and
(c) absence of osteitis [6,17].

The comorbidity factors in our study did not compromise the results. However, the patient numbers are too small to make any definitive recommendations on these comorbidity factors contributing toward an outcome.

Previous investigators have evaluated the results of various treatment strategies in dealing with complex soft-tissue defects of the knee. The gastrocnemius muscle remains the workhorse soft-tissue flap around the knee. Papp *et al.* [18] analyzed 10 patients with wound complications after TKA. In those treated with radical wound debridement and gastrocnemius muscle transfer, eight patients showed successful salvaging

of the knee joint. Ries and Bozic [14] evaluated 12 patients who sustained skin necrosis after TKA. In eight patients, the wound was located over the tibial tubercle or the patellar tendon, whereas the defect extended proximally to the patella or the quadriceps tendon in the other four.

A functional total knee was salvaged in 11 patients (92%) and healed primarily in all eight of those with more distal defects; however, three of the four patients with more proximal defects required additional fasciocutaneous, lateral gastrocnemius, or free flap coverage to provide adequate healing. The fourth patient in the more proximal group required above-knee amputation, leading the authors to conclude that the gastrocnemius should be reserved for more distal wounds around the knee. Gerwin *et al.* [8] evaluated the use of gastrocnemius muscle flaps in 12 patients, six of whom had exposed prostheses and six had infected hardware. In all six cases of infected prostheses, complete resolution of the infectious process was achieved with removal of the implant and muscle flap coverage, with five of six patients later undergoing successful reimplantation. In the six patients with exposed hardware, five retained their prosthesis and achieved excellent outcomes.

Jaureguito *et al.* [9] used medial gastrocnemius rotational flaps for extensor mechanism disruption in patients who had a TKA. In six patients, the mean extensor lag was reduced from 53 to 24° and the Knee Society knee and functional scores improved from 16 and 12 to 82 and 57, respectively. An extended gastrocnemius rotational flap, defined as including the medial half of the Achilles tendon, was used in two of the six patients. The extra length created allowed the surgeon to bypass the extensor mechanism with direct repair to the quadriceps, allowing reconstruction in the setting of large areas of discontinuity.

Our study has the following limitation. Although we performed complete follow-up on all patients, the number of patients studied was relatively small because of the limited pool of patients presenting with this devastating complication. Hence, a larger series of patients is needed to determine the effectiveness of this staged protocol for all patients who have early exposed septic knee prosthesis with patellar ligament disruption.

Conclusion

We believe that this two-staged protocol for prosthetic retention and skin coverage is a useful treatment method for the small subset of patients who present with early septic and exposed knee prosthesis with disruption of the patellar ligament. The findings from this study can provide the surgeon with an extra option to confront this devastating complication.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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