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Muscle Flaps in Total Knee Arthroplasty

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The results of 12 patients who had been treated with muscle flap coverage for compromised soft tissues associated with total knee arthroplasty were studied. Five latissimus dorsi free flaps, 6 medial gastrocnemius rotational flaps, and 2 rectus abdominis free flaps were done in 12 knees. The authors used and classified 3 types of muscle flaps: (1) prophylactic soft tissue coverage, done before definitive reconstruction; (2) treating muscle flap for infected prostheses with deficient soft tissue coverage; and (3) salvage muscle flap for wound dehiscence or necrosis in the immediate postoperative period. These patients were observed for an average of 4.1 years (range, 1–8 years). The wound was revascularized successfully in 100% of the knees. The prosthesis was preserved in 83% of the knees. Recurrent infection occurred in 3 patients. Treating muscle flaps are least likely to result in an overall successful reconstruction because these flaps are used in knees with chronic infection. Prophylactic flaps and salvage muscle flaps provide the soft tissue coverage necessary to allow successful reconstruction in the appropriate circumstances.

Wound dehiscence and exposed total joint prosthesis is fortunately very rare and, therefore, reports on its treatment are scarce.[1,6,7,12–14] However, the incidence of wound-healing problems in total knee arthroplasty has been reported to occur in as much as 20% of cases,[8,10] and many of these patients subsequently contribute to the overall incidence of infection that ranges from 1.1% to 12.4%.[11,16] Clinical risk factors for compromised wound healing include multiple previous surgeries, rheumatoid arthritis or other inflammatory arthritides, prednisone use, obesity, peripheral vascular disease, chronic renal insufficiency, previous infection, long-term tobacco and/or ethanol use, previous septic arthritis or osteomyelitis about the joint, severe malnutrition, previous irradiation or immunosuppressive therapy, and prolonged duration of the reconstructive operation.[5] Infection is the most serious potential complication in total joint arthroplasty, and the probability is increased with compromised wound healing.

Use of muscle flaps for treating soft tissue defects in knees with total joint prostheses has been reported previously.[1,6,7,12–14,16] The most successful muscle flap has been the gastrocnemius rotational flap with retention of the arthroplasty components.[5,7,12] In the literature, the overall experience with the use of muscle flaps for the successful treatment of exposed and infected prostheses is varied regarding successful soft tissue coverage and eradicating infection or exposed prostheses.[1,6,13,14] Few of the previous reports on the

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use of muscle flaps have determined the functional evaluation of the knee and the patient after this procedure is done. The purpose of this study is to report on the authors' experiences with the use of muscle flaps to treat soft tissue defects associated with total knee arthroplasty. Use of muscle flaps is classified into situations that allow a better determination of the prognosis which can be expected. The 3 types of muscle flaps classified are prophylactic muscle flap coverage done before the total knee arthroplasty, because of absent subcutaneous or muscle tissue about the knee; treating muscle flaps used for soft tissue defects in patients who have chronic infection associated with total knee arthroplasty; and salvage muscle flaps done in the immediate postoperative period for patients who have wound dehiscence or wound necrosis. The clinical results, as judged by the knee score and the functional score, also were studied in these patients.

MATERIALS AND METHODS

From 1987 to 1993, >1400 primary and revision total knee arthroplasties were done by 2 of the authors (LDD and KGV) at Centinela Hospital in Inglewood, CA. They identified 15 patients with 15 knees that had muscle flap coverage associated with total knee arthroplasty. Two patients had followup of <1 year, and 1 patient had not undergone subsequent implant surgery, so these patients were eliminated from this study group. A retrospective review was done on the 12 remaining patients. There were 7 men and 5 women, whose average age at the time of the soft tissue surgery was 56 years old (range, 30–80 years). The initial diagnosis that indicated total knee arthroplasty was osteoarthritis in 4 knees, rheumatoid arthritis in 4 knees, and posttraumatic arthritis in 4 knees. All patients had had previous surgery about the knee before total knee arthroplasty. Four patients had primary total knee arthroplasty and 8 patients had revision surgery. The prosthesis used in the 4 patients who received an index arthroplasty were 3 Apollo and 1 Natural knee designs (InterMedics Orthopaedics, Austin, TX). In the revision knee arthroplasties, 4 patients had constrained condylar knee implants (Zimmer, Warsaw, IN), 2 had a total condylar 3 design (Johnson & Johnson, Raynham, MA), 1 had a press-fit condylar posterior stabilized modular design (Johnson & Johnson), and 1 had a Kinematic rotating hinge (Howmedica, Rutherford, NJ).

Clinical outcome was evaluated by the Knee Society Clinical Rating System that separates the evaluation into a clinical score and a functional rating score.[9] For the knee scores and the functional scores, a score of 90 points or more was recorded as excellent, 80 to 89 good, 70 to 79 fair, and <70 poor. Postoperative followup averaged 49.1 months (range, 14–96 months), and all patients, except 1 who died at 14 months, were observed for >2 years. Assessment of the muscle flap included flap failure, necessity of reoperation, consolidation, development of infection, donor site morbidity, and presence of edema, flap pain, or swelling.

Muscle flaps were used only when a review of available management options revealed that straightforward, standard techniques, in all probability, would be inadequate, less reliable, and have a higher incidence of complications. The decision as to which flap to use for each knee was made by an experienced plastic surgeon (NEK). Factors such as the size, extent, and location of the defect, as well as the desire to minimize donor site morbidity, were considered. Generally, free flaps are used when the soft tissue lesion cannot be reached adequately or covered reliably by local flaps. All the muscle flaps were combined with overlying split thickness skin grafting. This obviated the use of myofasciocutaneous flaps. The patients also were treated with aspirin, elevation of the leg, and a warm ambient temperature, and avoided nicotine products during the immediate postoperative period. Patients were maintained at bedrest for 10 days. Active range of motion (ROM) exercises were begun on the tenth postoperative day. Limited weightbearing was used for 4 weeks with crutch-supported weightbearing to tolerance for an additional 4 weeks. Flap maturation required an average of 8 weeks, at which time consolidation of the flap was considered to have occurred. After consolidation, total knee arthroplasty can be done because an incision can be made through the flap, avoiding the vascular pedicle, without necrosis of the flap.

Four patients underwent prophylactic, treating, and salvage muscle flap coverage (Table 1). The interval, pertaining to the prophylactic group, was defined as the time elapsed between

TABLE 1. Muscle Flaps Associated With Total Knee Replacement

Case	Age (years)	Gender	Diagnosis	Followup (months)	Interval (weeks)	Indications(s)	Type of Flap
1	52	F	OA	36	16	Adherent skin to bone	MG—Prophylactic
2	55	F	OA	28	36,12	Adherent skin/scar to bone	LD, MG—Prophylactic
3	59	F	RA	81	16	Adherent skin/scar to bone	LD—Prophylactic
4	56	M	RA	53	16	Adherent skin/scar to bone	RA—Prophylactic
5	80	M	OA	64	—	Chronic infection, adherent scar	LD—Treating
6	68	M	Posttrauma	96	—	Chronic infection, adherent scar	LD—Treating
7	48	M	RA	71	—	Chronic infection, adherent scar	LD—Treating
8	30	M	Posttrauma	36	—	Chronic infection, adherent scar	RA—Treating
9	59	F	RA	14*	—	Skin slough, wound dehiscence	MG—Salvage
10	75	F	OA	24	—	Wound dehiscence	MG—Salvage
11	50	M	Posttrauma	24	—	Culture ± hemarthrosis	MG—Salvage
12	44	M	Posttrauma	45	—	Skin slough, culture ± hemarthrosis	MG—Salvage

MG = medial gastrocnemius rotational flap; LD = latissimus dorsi free flap; RA = rectus abdominis free flap; OA = osteoarthritis; RA = rheumatoid arthritis.

*Died of unrelated causes.

the soft tissue flap operation and the subsequent total knee arthroplasty. Two of these patients, with extensive scarring of the skin to the bone as a result of childhood osteomyelitis, had secondary degenerative osteoarthritis. Patient 2 had circumferential adhesive scarring, and required a latissimus dorsi free flap to the anterior knee done 36 weeks before knee arthroplasty and a medial gastrocnemius rotational flap placed posteromedially at an interval of 12 weeks. The other 2 patients with prophylactic muscle flaps had an underlying diagnoses of rheumatoid arthritis with adherent, hypertrophic scarring associated with a failed total knee arthroplasty. Patient 3 had a soft tissue deficit and a bony defect. A latissimus dorsi free flap was done before the revision total knee arthroplasty. At the time of the arthroplasty, a proximal tibial allograft was needed to reconstruct the tibia. In the revision patients, the index implant surgeries were done 20 and 156 months before the muscle flap procedures, respectively.

Treating muscle flaps were used in chronically infected total knee arthroplasties. The 4 patients in this group were treated with a 2-stage reimplantation for infected total knee arthroplasty.[8,14,16] Three of the patients had a Staphylococcus epidermidis infection and 1 had a Staphylococcus aureus infection requiring resection arthroplasty. In all 4 cases, the skin became adherent to the underlying bone and a free flap was done for soft tissue coverage. The reimplantation of the total knee prosthesis was done 2 months after the muscle flap in Patient 5. Patient 6 had an index total knee arthroplasty done 26 months after an open tibial plateau fracture. Complications from the tibial plateau fracture included a peroneal nerve palsy, nonunion, difficulty with wound healing, and posttraumatic arthrosis. Two years after his total knee arthroplasty, Staphylococcus epidermidis infection was present. A latissimus dorsi free flap was done to replace necrotic tissue at the lateral knee where drainage occurred. Initially, the implant was not removed. The infec-

tion was not controlled, so resection arthroplasty was done 4 months after the muscle flap operation. Reimplantation of the total knee prosthesis using a distal femoral allograft was done 12 months after resection arthroplasty. Patient 7 had rheumatoid arthritis, and 6.5 years years after index arthroplasty, a hematogenous Staphylococcus aureus infection developed. Resection arthroplasty and a latissimus dorsi free flap was done to attain soft tissue coverage. Reimplantation was done 4 months later. Patient 8 had a skin perforation at the site of lateral release at the time of index arthroplasty. This patient continuously drained through the skin perforation and an infection developed. Two months after primary implantation, resection arthroplasty was done. Two months later, a rectus abdominis free flap was done because of a persistent skin defect at the lateral soft tissues of the knee. Three months after the muscle flap procedure, reimplantation of a total knee prosthesis was done.

Postoperative salvage muscle flaps were done within 3 weeks of the arthroplasty in 4 patients. The medial gastrocnemius rotational flaps were done because of wound dehiscence, persistent drainage, or acute infection. Patient 9 had rheumatoid arthritis, and had wound dehiscence postoperatively because of compromise of the skin from previous operative treatments. A medial gastrocnemius rotational flap was done 7 days postoperatively. Patient 12 had undergone multiple previous surgeries, including collateral ligament reconstruction, patellectomy, and an extensor mechanism realignment procedure. The index total knee arthroplasty was complicated by disruption of the extensor mechanism requiring repair. Persistent wound drainage occurred in combination with Staphylococcus epidermidis infection that necessitated resection arthroplasty 18 months after total knee arthroplasty. Reimplantation was done 6 weeks later after appropriate treatment with intravenous antibiotics. Because of soft tissue necrosis over the distal wound, a medial gastrocnemius flap was done 2 weeks after reimplantation.

RESULTS

For this review, variables such as different types of prostheses, or primary versus revision procedures, were not considered to significantly affect the clinical results because of the complicating factors involved in the reconstruction in each of the patients. The muscle flaps healed in all of the knees. In no patient was the postoperative course complicated by a wound hematoma or hemarthrosis. Clinically significant deep venous thromboses or pulmonary emboli developed in none of the patients. In no patient was subsequent above knee amputation necessary. One patient had a resection arthroplasty at the knee as a final result and wore a stabilizing brace. Eleven patients were considered improved in their pain and function from their clinical situation before the treatment with the muscle flap. The patient who had the resection arthroplasty as a final result was considered to be not improved, but not worse. None of the patients were considered to be worse with the muscle flap and arthroplasty procedures (Table 2).

Three of the 4 patients with prophylactic muscle flaps had a good or excellent clinical result by knee score and functional score. The average clinical and functional scores improved to 85 from 48 points, and to 69 from 40 points, respectively. The postoperative arc of knee motion improved to 68° from 55°. Patient 2 did not improve in her ROM after the surgery, but her pain in the knee was significantly improved, as was her endurance capability for walking and standing. Patient 2 and Patient 8 had closed manipulations. There was no significant improvement in Patient 2 regarding ROM after manipulation. Excluding this patient, the postoperative arc of knee motion improved to 85°. A Staphylococcus aureus infection developed in Patient 3, diagnosed 39 months after a prophylactic latissimus dorsi flap, which intermittently drained. The patient was treated with suppressive oral antibiotics. Her clinical function was improved, because before the reconstructive surgery with the muscle flap and tibial allograft, the patient was not able to ambulate on her knee without pain and instability. At an average followup of 49.5 months, all these patients had improvement from their clinical situation before the muscle flaps and subsequent

TABLE 2. Outcomes of Muscle Flap Coverage

Case	Arc of Knee Motion		Knee Score (points)		Outcome
	Preoperative	*Postoperative*	*Clinical*	*Functional*	
1	10°–85°	0°–100°	90	80	Healed
2	10°–15°	0°–15°	85	80	Healed
3	10°–60°	10°–85°	70	45	Late infection
4	0°–90°	0°–80°	92	70	Healed
5	5°–85°	0°–90°	73	60	Recurred infection/second reimplantation
6	0°–90°	0°–90°	49	45	Recurred infection/resection arthroplasty
7	0°–90°	0°–90°	92	45	Healed
8	25°–75°	0°–85°	82	60	Healed
9	10°–30°	10°–90°	75	10	Healed
10	15°–125°	10°–90°	63	0	Healed
11	15°–120°	10°–120°	87	80	Healed
12	10°–50°	0°–100°	85	80	Healed

arthroplasty. All 4 patients improved regarding knee pain and functional abilities. Their muscle flaps healed without complications, and these patients had the least complaints of edema or flap pain. The only complication in this group was the late infection in Patient 3 that may have been associated with the tibial allograft.

The results in 2 of the 4 patients with treating flaps were not satisfactory. Late infections developed involving different organisms than those isolated as causative of the index infection. The average followup in this group was 66.8 months. The average clinical and functional scores improved to 74 and 53 points, respectively. The postoperative arc of knee motion improved to 89° from 78°. Patient 5 had recurrent infection that required reoperation with resection arthroplasty and subsequent reimplantation after treatment with the appropriate antibiotics. The patient had chronic pain in the knee. Patient 6 had recurrent infection that required resection arthroplasty and, postoperatively, functioned with the resection arthroplasty and use of a long leg double upright brace. This late infection also may have been associated with use of a large distal femoral allograft at the time of reimplantation. Patient 7 had an excellent result with return to the same clinical function as before the hematogenous infection. Six years after his treatment, infection had not recurred. Patient 8 had an acute infection from perforation of the skin at the time of index arthroplasty. The patient required a 2-stage reimplantation with a treating rectus abdominis muscle flap. The clinical course of this patient is more complicated than those who had a salvage muscle flap. The authors believe that if this patient had had a salvage muscle flap done within the first 2 to 3 weeks postoperatively, a 2-stage reimplantation, with the increased morbidity, could have been avoided. Overall, these patients had more reports of associated flap swelling and pain.

Use of postoperative salvage medial gastrocnemius flaps for patients with wound dehiscence or acute postoperative infection treated with debridement and muscle flap was successful. The average followup in this group was 31 months, excluding the patient who died. These muscle flaps were done within 3 weeks of the knee arthroplasty. Three of the 4 were done within 2 weeks of the arthroplasty. The average clinical and functional scores improved to 78 and 43 points, respectively. The postoperative arc of knee motion improved to 89° from 69°. Patient 9 had a

fair clinical result with the knee score and functional score because she had severe rheumatoid arthritis that compromised her function. Patient 12 had an acute postoperative infection with Staphylococcus epidermidis after reimplantation. These cultures persisted with drainage for 2 weeks after the muscle flap, and the patient was treated with an additional 6 weeks of intravenous antibiotics. At 4 years postoperation, the patient had a good clinical result without evidence of chronic or recurrent infection. Overall, use of postoperative salvage muscle flaps was successful in these patients. Salvage of the implant occurred in all 4 patients. The functional results in these patients were compromised by their overall clinical situation.

DISCUSSION

In the literature, the results with muscle flaps around knee arthroplasties have been generally pessimistic. Sanders and O'Neill[13] reported that only 4 operations were successful using gastrocnemius flaps for 9 total knee arthroplasties that had wound slough and exposed implants. The average time from the wound slough to the muscle flap operation was 3 months, and the length of followup was not specified.[12] Gerwin et al[6] reported on 12 knees with medial gastrocnemius coverage in 6 knees with exposed implants and 6 knees with chronically infected prostheses. In the 6 knees with exposed implants, muscle flap coverage was done at an average of 6 weeks after initial implantation. Length of time of implant exposure was not mentioned. The results of the patients with the exposed prostheses show that 5 knees retained their prostheses. The 6 patients with infected prostheses were treated with a 2-stage reimplantation with muscle flap coverage before reimplantation. In the 6 patients with infection, 5 of the patients had successful reimplantation at an average followup of 32 months. Clinical and functional scores were not reported. Siim et al[14] reported on 18 knees that had exposed implants treated with muscle flap operations. Their patients were observed for an average of 7 years (range, 1–17 years). Only 5 patients retained their prostheses, and 3 of these patients had considerable pain and poor mobility. The average time from exposure of the prosthesis to soft tissue coverage was 4 months. They recommended that reconstructive measures be instituted early at centers that have specialized, experienced staff. Adam et al[1] reported on 25 cases of exposed total knee replacements managed with fasciocutaneous and muscle flaps and followed an average of 5.4 years. Ten knees had aseptic wound slough and 90% of these knees had satisfactory healing of the muscle flap and preservation of the implant. Fifteen knees had infected necrosis that required medial gastrocnemius and latissimus dorsi flaps. The overall average delay between wound breakdown and flap coverage of the defect was 3.6 months (range, 1–9 months). In the infection group, only 60% of muscle flap procedures healed with preservation of the implant. Revascularization and wound healing occurred in 76% of cases; however, the overall functional outcomes had no excellent and only 50% good results as recorded with the British knee assessment chart.[2] In the present series, the wound was revascularized successfully in all 12 cases, and a functional prosthesis was preserved in all but 1 patient. Overall, 58% of the patients had a good or excellent result, as determined by the Knee Society clinical rating score.

Timing of the muscle flap is important for the success of the muscle flap and preservation of the implant. In patients who have adherent skin or scar tissue to bone, a prophylactic muscle flap should be done. To date, use of prophylactic muscle flaps in total knee arthroplasty has not been reported by others in the literature. In the patients in the present study, all 4 had satisfactory healing of the muscle flap and subsequent healing of the implant. A late infection occurred in 1 patient who had a large tibial allograft. It was the authors' supposition that the infection was caused by the

tibial allograft. Even in this patient, the functional result was satisfactory although the patient required oral antibiotics for suppression for the infection and had intermittent drainage. Certainly, it could have been anticipated that in all 4 of these patients postoperative wound slough and infection would have occurred if the muscle flap had not provided adequate soft tissue coverage preoperatively. In all 4 patients, use of a prophylactic muscle flap and subsequent total knee arthroplasty improved pain in the knee, and function of the knee and the patient.

Timing of postoperative salvage muscle flaps is also important to prevent development of infection that can become chronic. In all 4 of the patients presented here, early surgical debridement in combination with medial gastrocnemius flaps was successful in addressing wound necrosis, dehiscence, and culture-positive hemarthrosis in the postoperative period. In 1 patient in whom Staphylococcus epidermidis infection had developed, the infection was controlled by the operative use of the muscle flap and intravenous antibiotics. It has been shown that rotational flaps can bring in vascularity and provide an improved immune response[3]; however, a healthy flap cannot save a prosthesis that becomes infected beyond the immediate perioperative period. All 4 of these patients had a satisfactory result regarding pain relief and function. One of these patients (Patient 9) could only ambulate in her home because of her severe rheumatoid arthritis. She was very satisfied with her operation before her death because of the marked pain relief. The timing of these flaps is important because of the association with the development of chronic infection. In the studies by Borden and Gearen[3] and Teeny et al,[15] the development of chronic infection, which requires subsequent 2-stage reimplantation, is avoided only if acute infection is treated surgically within 2 weeks of the index arthroplasty. In the patients in the present study, wound slough and any infection were treated within 2 weeks in 3 of 4 patients, and in the fourth patient by the third week. The muscle flap was done to permit soft tissue coverage of the implant in the face of necrosis of the overlying soft tissues. The medial gastrocnemius rotational flap is mobile, and can be used to close defects on the lateral side of the knee.

The least successful muscle flap treatment was for soft tissue coverage in chronically infected total knee replacements. Two of 4 patients had recurrent infection, even after soft tissue coverage with muscle flaps. The recurrent infection necessitated resection arthroplasty. In 1 patient, a second reimplantation was done, and in the other resection arthroplasty was the final outcome. The time interval between resection arthroplasty, slough coverage, and reimplantation was several months in both patients (5 and 12 months, respectively), so that the recurrence of infection cannot be attributed to too short an interval between resection arthroplasty and reimplantation. This failure of muscle flap coverage to provide predictive results with chronic infection has been reported in other series.[1,12,13,15] In this group of patients, it is important to remember that muscle flaps do have a salutory effect on the infected wound and can provide the opportunity for future reimplantation. The difficulty in treating infected total knee arthroplasty is represented in the report by Windsor et al.[17] They reported a followup series of 38 knee arthroplasties treated with a 2-stage reimplantation protocol without the use of muscle flap coverage. With an average followup of 4 years, there was 1 documented recurrent infection with the original organism, and 3 subsequent infections with a different organism. In the present series, a subsequent infection with different organisms than that which caused the index infection developed in 2 of 4 comparable patients. The recurred infections were diagnosed >4 years after the muscle flap procedures. This study and the present study suggest that the successful treatment of the infected total knee arthroplasty represents the most difficult form of revision surgery.

The results in the patients who were treated with muscle flaps would indicate that the predictive success of muscle flap surgery for soft tissue defects around total knee prostheses is dependent on the reason for and the timing of the muscle flap. Patients in whom their soft tissue complications were treated with muscle flaps had variable results according to the type of muscle flap used within the classification presented. Patients who had treating muscle flaps for chronic infections had the worst results. Muscle flaps that were used prophylactically for soft tissue coverage for knees with adherent skin and scar tissue were successful. Patients with postoperative salvage muscle flaps that were done in the immediate postoperative period because of tissue necrosis from wound slough or infection also were successful.

Muscle flap coverage in total knee arthroplasty can be predictable in its success when the indications are defined, as has been done by the classification presented. With prophylactic muscle flap coverage, certain wound slough was avoided in each of the 4 patients. Postoperative salvage muscle flaps also are effective if the timing is correct. The decision to use a salvage muscle flap must be made within 2 to 3 weeks postoperatively. The muscle flap coverage cannot substitute for violation of the basic principles of successful treatment of infected total knee arthroplasties. Previous articles by Teeny et al[15] and Borden and Gearen[3] have shown that the occurrence of postoperative hematomas that are culture positive should be treated operatively within 2 weeks to have successful retention of the components. The muscle flap coverage in these cases is combined with this early postoperative debridement. The muscle flap coverage protects against recurrent drainage and infection from soft tissue defects that are present. Treating muscle flaps are not predictive regarding their success for eradication of infection, even when the soft tissue defect is treated. However, treating muscle flaps do provide an opportunity for reimplantation and may avoid the necessity of amputation. These treating flaps must be used with the understanding of this unpredictability of result. The series of patients presented in this article shows that the proper timing of muscle flap coverage can provide predictable and successful results when used in situations other than chronically infected total knee arthroplasties.

The authors currently are using the following guidelines to address the high risk patient, to avoid infection, and to preserve function. A prophylactic muscle flap is indicated when a realistic appraisal of the soft tissue integrity anticipates significant wound healing problems. The anticipated defect is usually large enough for consideration of a free vascularized muscle flap. The subsequent reconstructive procedure is delayed at least 12 weeks. If there is an infected total joint in which removal of the prosthetic components, scar tissue, synovium, and acrylic cement will create a soft tissue defect, a free tissue graft is done at the time of explantation. In this manner, soft tissue coverage is achieved and preservation of the patella is ensured because wound closure will not be under tension, and patellectomy thus is avoided. Slight wound drainage often requires no modification of the usual postoperative regimen. However, when profuse drainage associated with wound dehiscence or acute infection occurs, surgical debridement is done within 2 weeks of the index arthroplasty. If there is undue tension on wound closure, then a medial gastrocnemius rotational flap is done at the same operative session.

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