SUBSPECIALTY PROCEDURES

MEDIAL GASTROCNEMIUS FLAP IN THE COURSE OF TREATMENT FOR AN INFECTION AT THE SITE OF A TOTAL KNEE ARTHROPLASTY

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Introduction

The pedicled medial gastrocnemius flap provides a robust coverage option for most soft-tissue deficiencies over the distal anterior aspect of the knee encountered in the setting of an infection after total knee arthroplasty.

Although there are several techniques for providing coverage after an infection at the site of a total knee arthroplasty with overlying soft-tissue loss, the medial gastrocnemius flap remains the most common method of reconstruction for defects at or distal to the inferior pole of the patella¹⁻³. This axial pattern flap is particularly versatile because of its substantial size, mobility, ease of harvest, and minimal functional loss and donor-site morbidity^{3,4}. The medial head of the gastrocnemius is supplied by the medial sural artery and can be rotated to cover soft-tissue defects of the anterior distal aspect of the knee. The flap ranges from 5 to 9 cm in width and from 13 to 20 cm in length³. It provides a vascular bed for a skin graft and improves the delivery of oxygen, systemic antibiotics, and immune modulators to an infected joint^{1,5}.

Indications & Contraindications

Indications

- A soft-tissue deficiency over the anterior aspect of the knee during the course of treatment for deep infection. Medial gastrocnemius flap coverage is favored when full-thickness defects present exposed tendon, bone, or implant or when full-thickness surgical incisions are unable to be closed under appropriate tension, such as in the setting of infection when a draining sinus has been debrided. Flap coverage may be performed at the time of total knee replacement debridement with exchange of modular components, prosthetic explantation and antibiotic spacer placement, antibiotic spacer exchange, or second-stage prosthesis reimplantation.

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- A defect located over the distal part of the medial or anterior aspect of the knee. The medial gastrocnemius flap is most effective for the treatment of deficient soft tissue over the medial or anterior aspect of the knee located at or distal to the inferior pole of the patella (e.g., over the tibial tuberosity or patellar tendon).

Contraindications

- Superficial soft-tissue defects that are amenable to less extensive reconstructive modalities. Small superficial or partial-thickness skin defects may be managed with local wound care and healing by secondary intention provided that viable soft tissues are present and reepithelialization is expected in 10 to 14 days; debridement and skin-grafting can be utilized in these scenarios as needed. Negative-pressure vacuum-assisted closure followed by skin-grafting is a viable treatment option for full-thickness defects in the absence of infection, with deep tissue such as muscle or fascia that can form granulation tissue.
- Very proximal or lateral soft-tissue defects of the knee. Soft-tissue defects over the patella and quadriceps tendon that cannot be managed with skin-grafting or local wound care may not be suitable for coverage with the medial gastrocnemius flap alone because they may be beyond the arc of rotation of the muscle and vascular pedicle. Thigh-based coverage (gracilis, sartorius, or vastus muscle flaps or perforator soft-tissue flaps) or free flaps may be necessary for these more proximal defects in place of, or in addition to, a medial gastrocnemius flap. Similarly, a full-thickness defect involving the lateral aspect of the knee may require another coverage option, such as a lateral gastrocnemius or thigh-based flap.
- Defects exceeding the size of the medial gastrocnemius flap. As stated above, the medial gastrocnemius flap is 5 to 9 cm in width and 13 to 20 cm in length³. Defects exceeding its size may require alternative or additional modes of coverage. This technique may also not be ideal in elderly or very thin patients who may have smaller gastrocnemius muscle bellies.
- The blood supply of the flap has been compromised. The blood supply is very reliable unless there has been a knee dislocation or a substantially displaced supracondylar femoral fracture, which can damage the sural arteries. Similarly, compromise can arise if a patient has had a femoral popliteal vascular bypass because of either trauma or peripheral vascular disease. In these cases, an arteriogram must be obtained to confirm the patency of the sural arteries before attempting a local gastrocnemius transposition flap⁶.

Step 1: Patient Positioning

Position the patient supine with an ipsilateral sterile thigh tourniquet to allow room for harvest of a split-thickness skin graft as needed.

- Position the patient supine with osseous prominences well padded.
- In addition to sterile preparation of the involved extremity, which is done in a standard fashion, prepare an area of skin on the ipsilateral lateral aspect of the thigh as a donor site for the performance of a split-thickness skin graft for coverage of the flap.
- Place a sterile thigh tourniquet high on the ipsilateral thigh. In a patient with a long leg, the surgeon may instead choose to place a nonsterile thigh tourniquet prior to leg preparation.

Step 2: Revision Arthroplasty for Infection

Perform the arthroplasty to address the underlying deep infection (e.g., irrigation and debridement with exchange of modular components, component removal with antibiotic spacer placement, antibiotic spacer exchange, or second-stage reimplantation) prior to the medial gastrocnemius flap that is utilized for soft-tissue coverage.

- If a tourniquet is desired, inflate it at this time.
- Perform an anterior approach to the knee. Prior incisions should be considered when the surgical approach is planned. Reusing preexisting longitudinal incisions is preferred. Because the predominant blood supply to the anterior aspect of the knee arises medially⁷, if one is faced with multiple prior incisions, use of the lateralmost incision that provides adequate access to the joint is desired.
- Adhere to general infection principles, including obtaining tissue cultures; debridement of osseous, soft-tissue, and retained implant surfaces; and excision of any sinus tracts and devitalized tissue.
- Perform a tight joint capsule closure (with monofilament suture in the setting of infection) to the extent that this is possible in the presence of soft-tissue loss. While a layered closure of portions of the skin can be started at this time to gain an approximation of the final soft-tissue defect size, the skin is typically not fully reapproximated over its maximal possible length yet, as some additional space is needed for passage and inset of the flap.
- Once the revision arthroplasty is completed with accompanying debridement and some preliminary closure, reassess the extent of the residual soft-tissue defect. When the inclusion and exclusion criteria described above are met (Figs. 1-A and 1-B), proceed with medial gastrocnemius flap coverage.

Fig. 1-A

Fig. 1-B

Fig. 1-A An intraoperative photograph of a full-thickness soft-tissue defect over the distal anterior aspect of the knee that developed after static spacer placement for a deep periprosthetic joint infection. The patient had a history of chronic extensor mechanism deficiency. In the photograph, the thigh is located to the right while the proximal part of the shin is located on the left side. **Fig. 1-B** An intraoperative photograph showing the residual defect after thorough debridement and antibiotic spacer exchange. A capsular defect is noted in addition to the deficient extensor mechanism. The parameters of the defect remain amenable to medial gastrocnemius flap coverage.

Step 3: Incision and Approach for the Medial Gastrocnemius Flap

Use one of two different surgical approaches for the exposure and elevation of the medial gastrocnemius muscle and the identification of its vascular pedicle: the medial approach or the posterior midline approach.

- Outline the chosen incision on the skin.
 - The medial approach is performed via an incision placed 2 to 3 cm posterior to the medial border of the tibia, from the distal end of the muscle belly (approximately 8 to 10 cm proximal to the ankle) to the level of the popliteal fossa (Fig. 2). If the flap is to be tunneled under a skin bridge to reach an anterior defect, place the medial incision sufficiently posterior to ensure an adequate skin bridge of at least 7 cm to prevent skin necrosis⁶.
 - The posterior midline incision is placed directly between the medial and lateral muscle bellies, extending from the distal end of the muscle bellies through the popliteal fossa. A recent cadaver study found a safer dissection and greater muscle reach with the posterior midline approach⁸. However, the medial approach is more commonly utilized, given the relative ease of performing it in a supine position. Occasionally, a posterior midline approach can be performed with the patient positioned supine with a bump under the contralateral hip if the patient has excellent external rotation of the ipsilateral hip.
 - If a bump was used under the ipsilateral iliac crest for the arthroplasty procedure, the bump should be removed prior to flap harvest to allow the leg to externally rotate.
- Sharply incise the skin with a scalpel.
- Using either approach, dissect to the level of the gastrocnemius muscle fascia (Fig. 3), which is separated from overlying subcutaneous tissue.
- Take care to preserve the saphenous vein.

Fig. 2

Fig. 3

Fig. 2 A medial incision (hashed line) is placed 2 to 3 cm posterior to the medial border of the tibia (dotted line), extending from the distal end of the gastrocnemius muscle belly (on the right) to the level of the popliteal fossa (on the left). The incision is “cheated” slightly posteriorly to ensure an adequate skin bridge when it is tunneled subcutaneously to cover the defect over the anterior aspect of the knee.

Fig. 3 Dissection proceeds to the level of the gastrocnemius muscle fascia.

Step 4: Elevation of the Medial Gastrocnemius Flap

Protect the sural artery pedicle in the popliteal fossa because it is key to raising a viable medial gastrocnemius flap.

- Expose the medial gastrocnemius muscle along its length.
- Open the fascia of the superficial posterior compartment. Identify and bluntly develop the avascular plane between the gastrocnemius muscle and the underlying soleus muscle. Preserve the plantaris, which is located between these muscles (Fig. 4).
- Identify the median raphe between the medial and lateral heads of the gastrocnemius on the superficial surface of the muscle in the proximal third of the leg (Fig. 5). On the superficial surface, the sural nerve traverses the midline between the 2 heads proximally but then passes lateral to the raphe as it courses distally.
- Proceed with dissection of the muscle flap from distal to proximal. Distally, sharply detach the tendinous portion of the medial gastrocnemius muscle from its aponeurosis, beginning at the medial edge and extending to the median raphe, leaving an approximately 1-cm cuff of Achilles tendon attached to the flap (Fig. 6). Move proximally with the dissection in the midline along the raphe; the aponeurosis terminates and as the popliteal fossa region is approached, the 2 muscle heads can be bluntly separated (Fig. 7). Take care to protect the sural nerve proximally.

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 4 The avascular plane between the gastrocnemius muscle and the underlying soleus muscle is shown (the inferior retractor is located in this plane). The plantaris muscle (overlying the superior retractor) is located in this plane and should be preserved.

Fig. 5 The median raphe (blue arrow) between the medial and lateral heads of the gastrocnemius muscle is identified; the medial head (beneath the Senn rakes) is the larger muscle head. The sural nerve (white arrow) is visualized traversing the midline between the 2 heads proximally and then traveling lateral to the raphe as it courses distally.

Fig. 6 The medial gastrocnemius muscle is detached from its distal attachment using electrocautery. Dissection proceeds from the medial edge to the median raphe, leaving approximately a 1-cm cuff of Achilles tendon attached to the flap.

Fig. 7 Dissection of the medial head away from the lateral head along the median raphe has been completed as the flap is lifted up proximally.

- Elevate the medial gastrocnemius flap off the soleus muscle proximally up to the level of the popliteal fossa (Fig. 8). The medial sural artery (a branch of the popliteal artery) is the dominant blood supply of the medial head of the gastrocnemius muscle. It arises from the popliteal artery approximately 4 cm proximal to the knee joint and enters the proximal muscle approximately 3 cm proximal to the joint line⁶, where it arborizes. It is accompanied by 1 or 2 large veins, which lie just superficial to it and empty into the popliteal vein. A constant branch of the tibial nerve runs with the vessels to innervate the gastrocnemius muscle⁹. Given the proximal location of the pedicle behind the distal aspect of the femur, the pedicle rarely needs to be isolated to allow sufficient flap rotation for defects confined to the anterior distal aspect of the knee. Proximal dissection to the level of the popliteal fossa crease, but not beyond, will thus protect the more proximally located pedicle even without direct visualization, while a hand can safely be used to bluntly release proximal adhesions to the flap within the popliteal fossa.

Fig. 8

Fig. 8 The medial gastrocnemius muscle is elevated up to the level of the vascular pedicle. The elevator points in the direction of the pedicle (the medial sural artery) in the popliteal fossa. The pedicle is quite proximal and rarely needs to be isolated to allow sufficient flap rotation for coverage of defects confined to the anterior distal aspect of the knee (as in this case).

Step 5: Transposition and Insetting of the Flap Over the Defect

Rotate the flap and transpose it anteriorly over the defect either through a subcutaneous tunnel or by dividing the intervening skin bridge.

- After elevating the flap, rotate and transpose it over the defect on the anterior part of the knee. This is typically done by creating a subcutaneous tunnel on the medial aspect of the knee through which to pass the muscle (Fig. 9). Alternatively, the cutaneous bridge can be divided and the muscle laid directly over the defect. Utilize a clamp to grasp the peripheral fascia of the flap and manipulate the muscle belly to the desired position (Fig. 10). The flap should cover the defect with minimal tension. Ensure that the flap is not compressed between the skin bridge and the underlying pes anserinus fascia.
- Maximize the reach of the flap as needed. A number of techniques have been described to increase coverage provided by the gastrocnemius flap^{10,11}. A commonly used technique entails scoring or excision of the muscle fascia to increase length and width (Fig. 11). The neurovascular leash can also be isolated to the level of the popliteal vessels and the medial gastrocnemius muscle freed from the femoral condyle; the arc of rotation can be extended by 20% to 50%, or 5 to 8 cm, with dissection of the gastrocnemius muscle origin and the pes anserinus^{2,4,12}.
- When insetting the flap, use sharp dissection to subcutaneously undermine a few centimeters of tissue surrounding the defect in order to create a “pocket” to receive the inset flap. The flap will recede some with healing and thus should be set a few centimeters beyond the defect (Video 1).
- Suture the inset flap to surrounding soft tissue such that the flap overlies the defect and sits within the subcutaneous pocket created (Video 1). The sutures securing the flap should be peripherally located within the muscle (largely within the remaining cuff of aponeurosis and the peripheral fascia) to minimize strangulation of the muscle and its blood supply (Fig. 12).
- Take down the thigh tourniquet to verify perfusion of the flap and to expose the area of thigh that will be used for skin-grafting.

Fig. 9

Fig. 10

Fig. 11

Fig. 12

Fig. 9 A subcutaneous tunnel is created between the flap donor site and the soft-tissue defect on the anterior aspect of the knee, through which the flap may be passed.

Fig. 10 The rotated medial gastrocnemius muscle flap is tunneled beneath the skin bridge to the anterior knee defect.

Fig. 11 Scoring of the muscle fascia increases the excursion of the medial gastrocnemius flap.

Fig. 12 The tunneled flap is sutured into place over the soft-tissue defect in the anterior aspect of the knee.

Video 1 A cadaver dissection demonstrating the harvesting, transposition, and insetting of a medial gastrocnemius flap. (Reproduced, with permission, from: The Society of Military Orthopaedic Surgeons [SOMOS]. Copyright 2016. SOMOS core curriculum and critical skills list. <http://www.wheelessonline.com/ortho/12821>. Accessed 2016 Nov 3.)

Step 6: Closure, Skin-Grafting, and Dressing Application

Complete the layered skin closure and place a split-thickness skin graft over the remaining exposed muscle flap and a nonadherent compressive bolster dressing or negative-pressure device over the skin graft to prevent hematoma under the skin graft.

- Perform a layered closure of the fascia, subcutaneous tissues, and skin at the gastrocnemius flap donor site over a drain to prevent the formation of hematoma or seroma (Fig. 13).
- Complete the layered skin closure of the wound on the anterior aspect of the knee (utilizing monofilament suture in the setting of infection). Close the skin primarily to the extent that it is possible to approximate the wound edges without tension; the extent of feasible closure should have been estimated prior to inseting the flap so that appropriate flap positioning could be achieved. Consider interrupted mattress sutures for superficial closure in order to evert the wound edges. Where the skin cannot be approximated without tension, suture the skin flaps directly to the underlying muscle flap. Excise exposed fascia from visible muscle prior to skin-grafting in order to facilitate healing of the skin graft to the muscle below (Fig. 14).

Fig. 13

Fig. 14

Fig. 13 Layered closure of the gastrocnemius flap donor site is completed with an indwelling drain.

Fig. 14 A layered skin closure over the anterior aspect of the knee is performed. The proximal part of the skin is closed primarily without tension, using interrupted mattress sutures superficially to evert the wound edges. The skin distally is not amenable to tensionless primary closure; the skin edges are instead sutured to the underlying muscle flap. The fascia on the exposed muscle flap has been excised to facilitate healing of the skin graft.

- Place a split-thickness skin graft over the remaining defect. Use a sterile ruler to measure the size of the residual wound to be addressed with skin-grafting. Outline a template of the skin graft to be harvested on the ipsilateral thigh using a gentian violet marker; this should be larger than the residual wound to ensure adequate wound coverage (Fig. 15). We prefer to subcutaneously inject the skin graft harvest site with a combination of local anesthetic and epinephrine for the purposes of analgesia and control of bleeding. Harvest the skin graft utilizing a dermatome (Fig. 16). Use a skin-meshing machine to mesh the graft, typically at a 1.5:1 ratio; sheet grafts (unmeshed) have a greater tendency to develop subgraft seromas and hematomas, which can lead to graft loss. Place the graft in the wound with the dermis side down (Fig. 17). Use either staples or sutures (3-0 chromic) around the periphery of the skin graft to hold it in place (Fig. 18). Trim excess peripheral skin graft by holding it taut with forceps and using scissors (Fig. 19). Once the excess has been removed and the entire peripheral edge of the skin graft has been secured (Fig. 20), any surface irregularity leading to noncontact with the undersurface of the graft can be addressed by placement of quilting sutures; these are absorbable (e.g., 4-0 chromic) sutures placed through the skin graft to draw the deep surface of the graft into contact with the muscle.

Fig. 15

Fig. 16

Fig. 17

Fig. 18

Fig. 19

Fig. 20

Fig. 15 The harvest site for the split-thickness skin graft is outlined on the ipsilateral thigh.

Fig. 16 A split-thickness skin graft is harvested with a dermatome after subcutaneous infiltration with a combination of local anesthetic and epinephrine. The dermatome can be set to the desired harvest depth and width.

Fig. 17 The meshed split-thickness skin graft is placed in the wound dermis side down.

Fig. 18 The skin graft is secured in place using sutures around the periphery.

Fig. 19 Excess peripheral skin graft is trimmed.

Fig. 20 The wound after inset and trimming of a meshed split-thickness skin graft.

- Place a nonadherent interface (e.g., Xeroform [Kendall], Aquaphor gauze [Beiersdorf], and ACTICOAT dressing [Smith & Nephew]) over the skin graft to prevent the graft from adhering to the bolster or negative-pressure wound therapy device that will further secure the graft in position. If a negative-pressure wound therapy device (e.g., Vacuum-Assisted Closure [V.A.C.]; Acelity) is used, one may staple the nonadherent interface directly to the portion of sponge that will overlie the skin graft (Fig. 21). Negative-pressure wound therapy is not recommended for unmeshed grafts.
- Finish dressing the skin graft using an overlying bolster dressing (consisting of Reston foam [3M] or cotton batting secured with gauze and an elastic wrap) or negative-pressure wound therapy. If vacuum-assisted closure is utilized, one may incorporate the adjoining incision within the negative-pressure construct (Fig. 22); if the incision is incorporated, place a permeable, nonadherent dressing (e.g., ADAPTIC; Acelity) between the skin and sponge to prevent maceration of the wound edges. The negative-pressure device is generally set to continuous at 75 mm Hg.
- Place a sterile dressing over the closed incision at the gastrocnemius donor site.
- Place a nonadherent interface (e.g., Xeroform) over the skin graft harvest site.
- Apply a bulky Jones dressing with an overlying elastic bandage from the toes to the thigh, incorporating the gastrocnemius incision and knee wound but stopping distal to the skin graft harvest site, which should be left open to air.
- Immobilize the knee in extension.

Fig. 21

Fig. 22

Fig. 21 A nonadherent dressing (ACTICOAT; Smith & Nephew) is stapled to the undersurface of the vacuum-assisted closure sponge in the area that will overlie the split-thickness skin graft.

Fig. 22 Negative-pressure wound therapy is applied over the skin graft site (inferiorly) and adjoining incision (superiorly).

Step 7: Postoperative Care

Progress range of motion of the knee once the flap and graft show evidence of survival, while an appropriate antibiotic regimen is completed.

- Remove indwelling drains when output is sufficiently low for consecutive shifts (<20 mL), typically on the first or second day postoperatively.
- On postoperative day 5, remove dressings and examine the wound. Typically at this time, the skin graft will have acquired a pink coloration, and while most fenestrated areas may not be fully epithelialized, it should be apparent that graft incorporation is under way.
- As early graft-healing occurs, briefly transition to routine wet-to-dry dressing changes over the skin graft 3 times per day. Once early graft-healing has occurred, usually at 2 to 3 weeks, the regular application of moisturizer (hypoallergenic emollient cream) for about 4 weeks helps to keep the graft supple and promotes slough of scaling stratum corneum and eschar.
- When a static spacer is not in place, typically begin range of motion of the knee at 2 to 3 weeks, once the flap and skin graft show good evidence of survival.
- The duration of antibiotics administered postoperatively depends on the arthroplasty procedure performed at the time of flap coverage. Culture-targeted intravenous antibiotics should generally be administered for a minimum of 6 weeks in patients undergoing treatment for a deep periprosthetic joint infection, with the exception of patients undergoing second-stage reimplantation.

Results

We recently reported the largest English-language series, to our knowledge, of medial gastrocnemius flaps performed for soft-tissue coverage in the course of treatment for infection after total knee arthroplasty¹³. Between 2003 and 2011, 31 patients underwent such flap procedures at our institution utilizing the technique described above. Of the 27 patients with complete follow-up, six had the flap done at the time of prosthetic explantation and antibiotic spacer placement; 8, at the time of a spacer exchange; 8, at the time of the second-stage reimplantation; and 5, at the time of debridement with modular polyethylene exchange. The decision about when during staged treatment to perform the flap procedure was made solely on the basis of when the soft tissues were deemed insufficient and not on the basis of a belief that placement at one stage rather than another was advantageous.

Twenty-seven (87%) of the 31 patients were followed for a minimum of 2 years (mean, 4 years; range, 2 to 6 years). Failure was defined as the inability to undergo reimplantation of a total knee arthroplasty prosthesis or recurrence of periprosthetic joint infection. Fourteen (52%) of the 27 patients had a persistent or recurrent infection; survivorship of the total knee arthroplasty components at 4 years was 48% (95% confidence interval, 31% to 66%). Although there were no flap-related complications, 12 patients had a total of 19 reoperations during the study period. The reoperations, which were done in the patients who had a persistent or recurrent infection, consisted of 6 knee arthrodeses with 1 distal femoral replacement after a failed arthrodesis; 5 irrigation and debridement procedures with polyethylene exchange; 4 total knee arthroplasty prosthesis explantations with antibiotic spacer placement; and an above-the-knee amputation, a tibial component revision for periprosthetic fracture, and a subsequent replantation of a prosthesis in 1 patient each. For the entire cohort, the mean Knee Society knee score (and standard deviation) improved from 38 ± 18 preoperatively to 65 ± 20 postoperatively ($p < 0.001$) and the mean Knee Society function score, from 20 ± 22 to 37 ± 25 , respectively ($p = 0.002$), at the most recent follow-up. With the numbers available, no factors reached significance for an association with failure when a Bonferroni correction was applied. However, a trend toward failure was detected when flap coverage was done at the same time that an antibiotic spacer was placed or a spacer was exchanged compared with when flap coverage was done at the time of irrigation and debridement or reimplantation of a prosthesis (71% versus 31%; $p = 0.033$).

In this large retrospective series, the fact that all flaps reliably healed suggests that the relatively high proportion of patients who experienced persistent or recurrent infections was related to case complexity and not necessarily to a problem with flap choice or technique. For perspective, the success of 2-stage exchange arthroplasty for periprosthetic joint infection has been reported to range from 66% to 91% in several large series¹⁴⁻¹⁷ when flap coverage was not required. Previous studies^{16,18,19} have concurred that the results of 2-stage exchange arthroplasty for infection are worse in knees with soft-tissue compromise warranting flap reconstruction. Although acceptable outcomes have been reported after a gastrocnemius flap procedure at first-stage resection of a total knee arthroplasty²⁰ and at second-stage reimplantation²¹, we found that, in a 2-stage exchange arthroplasty, delaying flap coverage until after the infection has been treated may be advisable if the soft tissue is able to be closed at the time of resection or spacer exchange. Medial gastrocnemius flap procedures performed over total knee replacements for soft-tissue defects in the absence of deep infection (e.g., for skin necrosis) have been shown to yield superior results compared with such procedures performed in the infected setting².

Pitfalls & Challenges

- To prevent compromise of the pedicled blood supply of the flap and subsequent flap necrosis, minimization of tension at all steps, from flap mobilization to soft-tissue closure, is key. Ways to maximize excursion of the flap, including scoring or excision of its fascia, more proximal isolation of its neurovascular leash, and release of the medial head from the femoral condyle, are described above. The medial gastrocnemius flap also can be used in conjunction with other local or regional flaps for coverage of larger defects that extend beyond its reach.
- Stiffness may be an issue after flap coverage and subsequent immobilization. While soft-tissue healing should be the initial priority, it is prudent to begin progressive knee range of motion, when possible, once the graft and flap show signs of incorporation. We generally immobilize the knee in extension for 2 to 3 weeks; investigators who have reported beginning knee range of motion as early as 10 days also reported a higher rate of wound complications²¹.
- The donor site morbidity associated with the flap procedure is generally minimal because of compensation provided by the remaining soleus and hemigastrocnemius muscle^{22,23}.
- There is limited evidence regarding risk factors for treatment failure, but optimization of modifiable patient characteristics (e.g., tobacco use^{24,25}, diabetic control²⁴, and steroid use²⁴) is advisable perioperatively.

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References

1. Gerwin M, Rothaus KO, Windsor RE, Brause BD, Insall JN. Gastrocnemius muscle flap coverage of exposed or infected knee prostheses. *Clin Orthop Relat Res.* 1993 Jan;286:64-70.
2. Ries MD, Bozic KJ. Medial gastrocnemius flap coverage for treatment of skin necrosis after total knee arthroplasty. *Clin Orthop Relat Res.* 2006 May;446:186-92.

3. Osei DA, Rebehn KA, Boyer MI. Soft-tissue defects after total knee arthroplasty: management and reconstruction. *J Am Acad Orthop Surg.* 2016 Nov;24(11):769-79.
4. Veber M, Vaz G, Braye F, Carret JP, Saint-Cyr M, Rohrich RJ, Mojallal A. Anatomical study of the medial gastrocnemius muscle flap: a quantitative assessment of the arc of rotation. *Plast Reconstr Surg.* 2011 Jul;128(1):181-7.
5. Panni AS, Vasso M, Cerciello S, Salgarello M. Wound complications in total knee arthroplasty. Which flap is to be used? With or without retention of prosthesis? *Knee Surg Sports Traumatol Arthrosc.* 2011 Jul;19(7):1060-8. Epub 2010 Dec 15.
6. Bos GD, Buehler MJ. Lower-extremity local flaps. *J Am Acad Orthop Surg.* 1994 Nov;2(6):342-51.
7. Lazaro LE, Cross MB, Lorch DG. Vascular anatomy of the patella: implications for total knee arthroplasty surgical approaches. *Knee.* 2014 Jun;21(3):655-60. Epub 2014 Apr 2.
8. Lamarinis GA, Carlisle MP, Durand P, Couto RA, Hendrickson MF. Maximizing the reach of the pedicled gastrocnemius muscle flap: a comparison of 2 surgical approaches. *Ann Plast Surg.* 2017 Mar;78(3):342-6.
9. Feldman JJ, Cohen BE, May JW Jr. The medial gastrocnemius myocutaneous flap. *Plast Reconstr Surg.* 1978 Apr;61(4):531-9.
10. Arnold PG, Mixter RC. Making the most of the gastrocnemius muscles. *Plast Reconstr Surg.* 1983 Jul;72(1):38-48.
11. Smet HT. Tissue transfers in reconstructive surgery. New York: Raven Press; 1989. p 175-8.
12. Andres LA, Casey WJ, Clarke HD. Techniques in soft tissue coverage around the knee. *Tech Knee Surg.* 2009;8(2):119-25.
13. Tetreault MW, Della Valle CJ, Bohl DD, Lodha SJ, Biswas D, Wysocki RW. What factors influence the success of medial gastrocnemius flaps in the treatment of infected TKAs? *Clin Orthop Relat Res.* 2016 Mar;474(3):752-63. Epub 2015 Nov 16.
14. Goldman RT, Scuderi GR, Insall JN. 2-stage reimplantation for infected total knee replacement. *Clin Orthop Relat Res.* 1996 Oct;331:118-24.
15. Mittal Y, Fehring TK, Hanssen A, Marculescu C, Odum SM, Osmon D. Two-stage reimplantation for periprosthetic knee infection involving resistant organisms. *J Bone Joint Surg Am.* 2007 Jun;89(6):1227-31.
16. Mortazavi SM, Vegari D, Ho A, Zmistowski B, Parvizi J. Two-stage exchange arthroplasty for infected total knee arthroplasty: predictors of failure. *Clin Orthop Relat Res.* 2011 Nov;469(11):3049-54.
17. Sherrell JC, Fehring TK, Odum S, Hansen E, Zmistowski B, Dennis A, Kalore N; Periprosthetic Infection Consortium. The Chitranjan Ranawat Award: fate of two-stage reimplantation after failed irrigation and débridement for periprosthetic knee infection. *Clin Orthop Relat Res.* 2011 Jan;469(1):18-25.
18. Galat DD, McGovern SC, Larson DR, Harrington JR, Hanssen AD, Clarke HD. Surgical treatment of early wound complications following primary total knee arthroplasty. *J Bone Joint Surg Am.* 2009 Jan;91(1):48-54.
19. Nahabedian MY, Mont MA, Orlando JC, Delanois RE, Hungerford DS. Operative management and outcome of complex wounds following total knee arthroplasty. *Plast Reconstr Surg.* 1999 Nov;104(6):1688-97.
20. Corten K, Struelens B, Evans B, Graham E, Bourne RB, MacDonald SJ. Gastrocnemius flap reconstruction of soft-tissue defects following infected total knee replacement. *Bone Joint J.* 2013 Sep;95-B(9):1217-21.
21. McPherson EJ, Patzakis MJ, Gross JE, Holtom PD, Song M, Dorr LD. Infected total knee arthroplasty. Two-stage reimplantation with a gastrocnemius rotational flap. *Clin Orthop Relat Res.* 1997 Aug;341:73-81.
22. Harris IE, Leff AR, Gitelis S, Simon MA. Function after amputation, arthrodesis, or arthroplasty for tumors about the knee. *J Bone Joint Surg Am.* 1990 Dec;72(10):1477-85.
23. McCraw JB, Fishman JH, Sharzer LA. The versatile gastrocnemius myocutaneous flap. *Plast Reconstr Surg.* 1978 Jul;62(1):15-23.
24. Menderes A, Demirdover C, Yilmaz M, Vayvada H, Barutcu A. Reconstruction of soft tissue defects following total knee arthroplasty. *Knee.* 2002 Sep;9(3):215-9.
25. Tan KJ, Lim CT, Lim AY. The use of muscle flaps in the salvage of infected exposed implants for internal fixation. *J Bone Joint Surg Br.* 2010 Mar;92(3):401-5.