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Complications - Other

Incisional Management in the Multiply Operated Total Knee Arthroplasty

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ABSTRACT

Total knee arthroplasty in the setting of multiple previous skin incisions can be a complex clinical scenario for the arthroplasty surgeon. Inappropriate incision choice can lead to devastating complications such as skin necrosis and its sequelae, including periprosthetic joint infection and the need for flap reconstruction. It is therefore critical for knee surgeons to understand the blood supply to the anterior aspect of the knee to prevent adverse outcomes. This article challenges some of the long-held dogma regarding incisional management for total knee arthroplasty and utilizes case examples to demonstrate that skin necrosis between parallel incisions can be avoided by utilizing an existing lateral incision with full-thickness subfascial skin flaps.

The annual number of total knee arthroplasties (TKAs) is increasing, with approximately 935,000 procedures projected by 2030 [1]. As the volume of TKAs steadily increases, complications associated with this procedure rise concurrently. The incidence of wound complications after TKA can range from benign physiologic drainage to gross necrosis of skin flaps, with the latter being one of the most devastating outcomes following TKA [2,3]. Previous surgery is one of the biggest risk factors for wound-related problems [2,4]. Patients present for primary or revision TKA from several different pathways. These include post-traumatic arthritis, pediatric deformity surgery, and prior sports-related soft tissue procedures. All these previous procedures can lead to the complex clinical scenario of arthroplasty in the setting of multiple incisions about the knee (Figure 1). As the incidence of TKA continues to increase after previous open surgeries, arthroplasty surgeons will be faced with the challenging question of what incision to choose when faced with a patient undergoing a TKA with multiple previous healed incisions.

As arthroplasty surgeons, we all can relate to the moment when the patient has been prepped and draped, the timeout has been performed, and we are left to decide as we gaze upon a knee with multiple incisions (Figure 1). Unfortunately, this decision can be difficult, as a patient who has multiple incisions requiring TKA is not always encountered during residency training. Hence, how to manage a patient like this is not always stressed as a part of basic arthroplasty training for residents. Therefore, unless the vascular anatomy of the skin on the anterior knee is clearly understood by knee arthroplasty surgeons, a wrong choice at this time can have devastating consequences. In our Prosthetic Joint Infection Center, we have been referred to 10 patients in the last 2 years with skin necrosis, leading to the need for implant resection and flap coverage. These patients were referred by multiple different surgeons who trained at reputable residency programs and were unaware of the basic principles of incision management in a multiply operated knee. This is not the experience of a single surgeon. The cases were treated by multiple surgeons at our Prosthetic Joint Infection Center dealing with referred patients from various community orthopaedic surgeons that were unaware of basic incision and wound management principles that led to disastrous results ranging from the need for a gastrocnemius flap or even amputation. To this end, this paper will

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Figure 1. Preoperative clinical picture demonstrating a knee with multiple healed incisions. The dotted line shows the previous medial incisions. The solid lines with hash marks notes the lateral healed incision with extension both distally and proximally. The lateral incision was utilized for total knee arthroplasty in this case.

discuss the evidence-based principles that must be followed regarding soft-tissue management to help avoid disastrous wound complications following TKA. The decision-making stakes are high at this time, as an error in judgment can lead to extensive skin necrosis resulting in prosthetic joint infection and the need for a gastrocnemius flap for coverage (Figures 2A to C). In the process, we hope to challenge some of the long held dogma and conventional wisdom that, in our experience, has proven to be problematic.

Vascular Anatomy

To properly discuss treatment principles, it is important for every knee arthroplasty surgeon to understand the blood supply to the soft tissue of the knee. Branches of the femoral artery, popliteal artery, and the anterior tibial artery provide the major blood supply about the knee [5]. The skin surrounding the knee is perfused through an anastomosis of vessels just superficial to the deep fascia, fed by underlying perforating vessels [5–8]. The anterior and medial aspects of the knee are supplied by the saphenous branch of the descending genicular artery, with a small contribution anterior inferiorly from the anterior tibial recurrent artery [5]. Thus, the major blood supply to the anterior skin of the knee is derived from a mainly medial source. Laterally, the deep fascial plexus is derived from the superior and inferior lateral genicular branches of the popliteal artery [5], but provides a much smaller percentage of the overall blood supply to the anterior knee compared to the medial source. Simply put, the blood supply to the anterior aspect of the knee comes in from medial to lateral.

It is also important to understand the local microcirculation of the skin. A deep subfascial vascular network sends vessels that penetrate the subcutaneous fat and ultimately supply the epidermis. Since the anastomosis of vessels that supplies the skin lies just above the fascia, it is critical to preserve the plane between the subcutaneous tissue and the fascia during flap dissection. When raising a flap, you must stay below the levels of the fascia, elevating the fascia, subcutaneous tissue, and skin up as a unit (Figures 3A and B). This is the reasoning behind the teaching to develop full-thickness skin flaps that are vital in maintaining blood supply, as this vital anastomosis occurs at the fascial level. Thus, if your flaps are not full thickness, that is, subfascial, you are in essence cutting off blood supply to the skin, which may be disastrous.

With the understanding of the vascular supply to the front of the knee, it becomes imperative when parallel medial and lateral

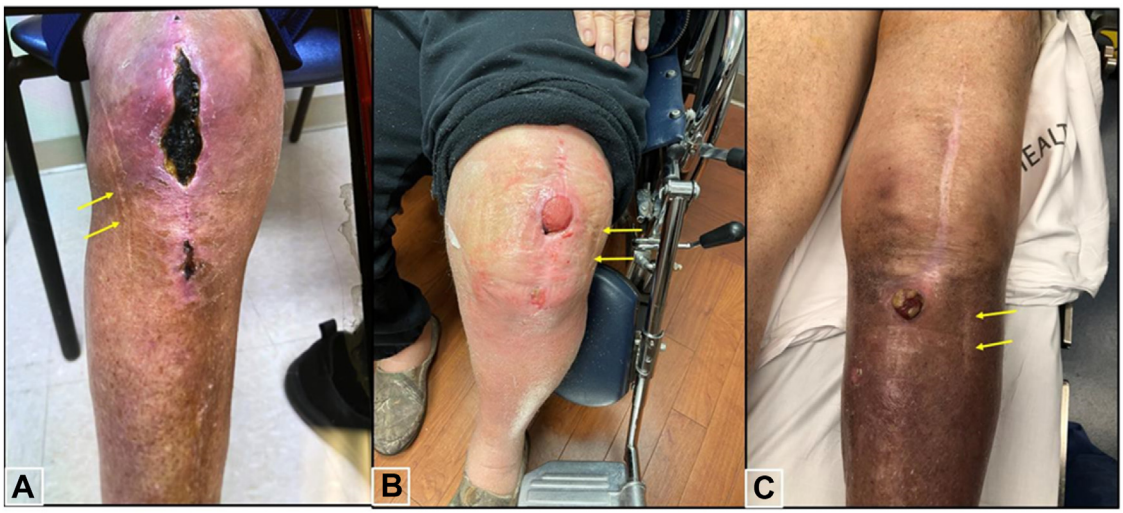

Figure 2. Cases demonstrating major skin necrosis and wound breakdown after a medial incision was utilized for total knee arthroplasty in the setting of previous remote laterally healed incision.

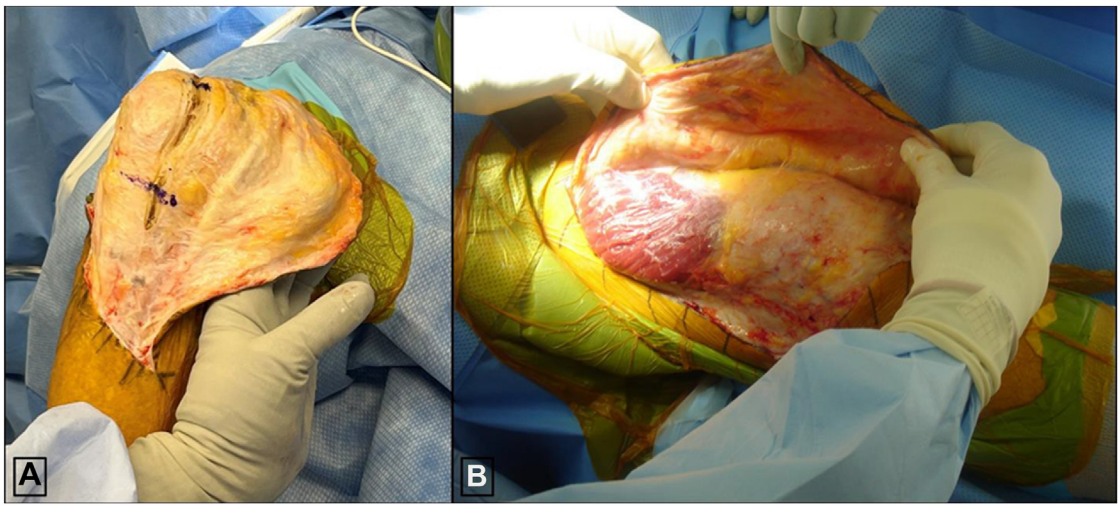

Figure 3. A-B. 3 Medially based subfascial flaps using a previous lateral incision.

incisions are encountered that one uses the most laterally based incision available. Failure to do so risks cutting off the blood supply to the skin between the incisions. It is also critical to always use the most lateral incision even if there is not a medial incision. Making a midline incision to perform an arthroplasty when a lateral incision only is present is dangerous and jeopardizes the skin between the incisions by cutting off the blood supply that comes from medial to lateral (Figure 2A to C). Large medially based subfascial flaps are the safest way to expose a knee with a previous lateral incision. These medially based subfascial flaps can be quite large and heal uneventfully provided they are raised in a subfascial manner (Figure 4). A medial parapatellar arthrotomy is still able to be used by creating a subfascial medially based flap.

We have little experience with tissue expanders to manage the multiply incised knee, reserving this technique for situations where skin is adherent to the bone of the anterior knee. Prior lateral incisions that are distal or proximal to a planned midline incision can be ignored. We have no data to make a specific recommendation on whether the length of the lateral incision or the number of incisions in a multiply incised knee should affect decision-making.

Figure 4. Case examples demonstrating utilization of lateral incisions with healed full-thickness subfascial flaps.

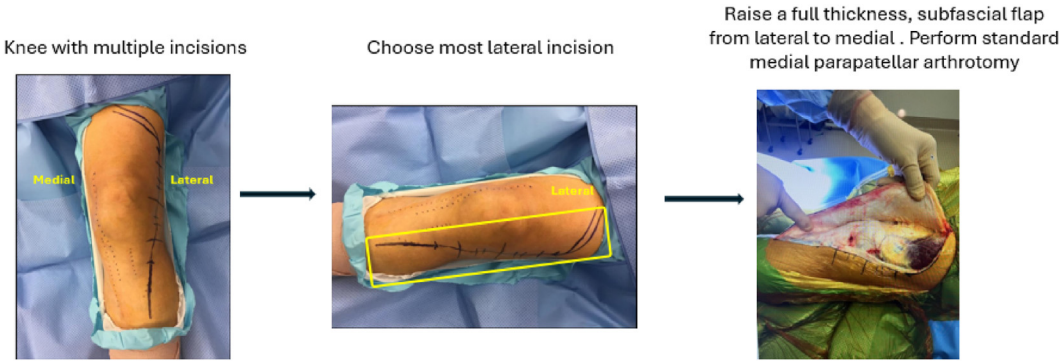

Figure 5. Decision algorithm for a knee with multiple previous incisions.

However, a clear understanding of the vascular anatomy of the anterior skin of the knee and an understanding of the problems that could occur if a wrong decision is made make it prudent to utilize the most lateral incision as a matter of surgical routine. The algorithm is very simple. When encountering multiple incisions, the surgeon should always use the most lateral incision to avoid skin necrosis (Decision Algorithm, Figure 5).

There are certain theories that we wish to challenge that are easy for the arthroplasty surgeon to adopt out of convenience and lack of comfort. The first of which is the "distance" dogma, which assumes that a 7 to 8 cm distance between parallel incisions is enough of a skin bridge to be safe. We have found this to not be true, as we have had multiple referrals to our center for disastrous wound complications after using a parallel incision in the setting of an "adequate" skin bridge. This is highlighted in a recent study by Yeganeh et al. [9]. This study consisted of a randomized control study assessing whether a minimum 8-cm skin bridge was necessary to prevent skin necrosis in TKA. In this study, one of 25 patients who had a skin bridge > eight centimeters had devastating skin necrosis. This patient had a lateral incision that was ignored. An anterior midline incision was chosen, and the intervening skin bridge necrosed. They concluded that because skin necrosis occurred in only one patient, it is acceptable to ignore previous longitudinal incisions and make a standard midline incision regardless of the presence of a previous healed incision. *We would argue the exact opposite*. If one out of 25 patients (4%) suffers major skin necrosis because the most lateral incision was not utilized, then this risk is too big when there is an alternative. We are confident the involved patient would agree. We would argue that using the most lateral incision in a subfascial manner can prevent this unnecessary complication and that no amount of skin bridge is safe to prevent this complication.

The other misconception we would like to address is "duration" from previous surgery dogma. This assumes that if much time has passed between incisions, then revascularization is adequate to tolerate any skin incision regardless of the location of other incisions. We again urge against this concept, as we have had several referral patients who have catastrophic wound issues using incisions that were assumed to be "revascularized" over time. Transverse incisions about the knee can be crossed safely at right angles, and oblique incisions can usually be incorporated into the wound; however, any lateral incision should be utilized when present, remembering to

Figure 6. (A) Case example of major skin necrosis and wound breakdown of the intervening skin bridge in a case where a remote lateral incision was ignored and a medial incision was utilized for total knee arthroplasty. (B) Healed gastrocnemius muscle flap following resection and debridement.

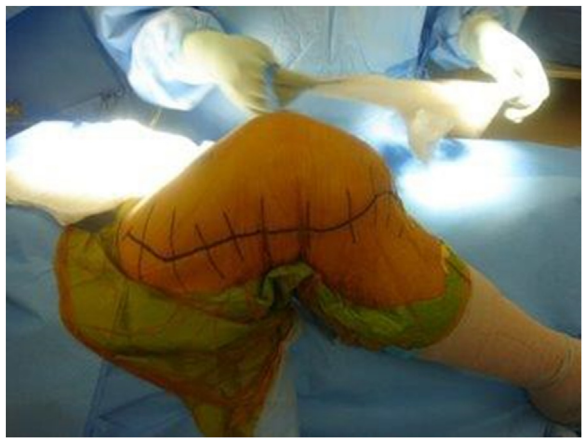

Figure 7. Preoperative case example of a patient who had a large S-shaped incision about the knee.

stay subfascial while raising a medially based flap. Using a midline incision when a lateral incision is available must be avoided to prevent catastrophic wound complications that can lead to a prosthetic joint infection and gastrocnemius flap coverage. The case examples below highlight these critical principles.

Postoperative Management

The postarthroplasty management of revision or complicated primary total knee in the setting of previous incisions should be considered on a case-by-case basis. It is our recommendation to take all precautions necessary to increase soft tissue survival in the setting of tenuous skin flaps. We routinely implement the use of superficial drains to prevent hematoma formation and minimize dead space. Postoperative range of motion is held initially, immobilizing the patient for as long as necessary to allow tension-free healing of created flaps. Cryotherapy is a common adjunct tool in orthopaedic surgery; however, there have been reports of skin necrosis secondary to frostbite after TKA [10]. In patients who have compromised soft-tissue envelopes, the blood flow and tissue oxygen levels are at risk after flap creation. We, therefore, minimize this risk by not allowing cryotherapy in the immediate postoperative period, as the vasoconstriction created by the ice can add insult to an already compromised soft tissue envelope.

Case Examples

Case 1

The first example is a 79-year-old morbidly obese man who had uncontrolled diabetes who underwent a primary TKA complicated by patellar maltracking. He had a previous remote history of an unknown knee surgery utilizing a laterally based incision. However, for the primary knee surgery, a midline skin incision was used. Subsequently, the patient was referred to us due to a nonhealing wound and a major soft-tissue defect on the distal and lateral aspect of his knee between the previous lateral incision and the fresh midline incision (Figure 6A). Ultimately, the patient underwent resection arthroplasty, with implantation of an antibiotic spacer, lateral gastrocnemius flap, and split-thickness skin grafting. Three months later, after adequate healing, his prosthetic knee was reimplanted (Figure 6B).

Case 2

A 68-year-old man who underwent a remote open reduction and internal fixation using a lateral distal femoral plate presented with post-traumatic arthritis and requested a TKA. A lateral S-shaped incision was identified preoperatively (Figure 7). A full-thickness lateral incision was utilized (Figure 8A-B). The incision healed uneventfully.

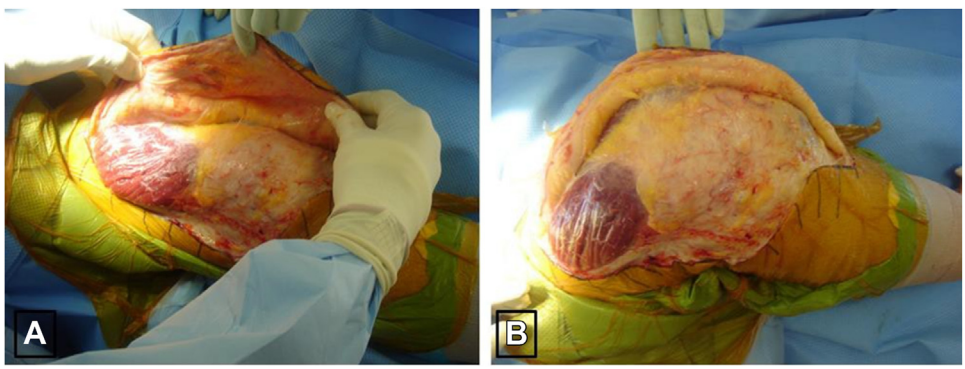

Figure 8. A-B. Intraoperative clinical picture of the patient in Figure 7 demonstrating a full-thickness subfascial flap created for medial parapatellar arthrotomy.

Table 1
Various Approaches for Exposure in Revision Total Knee Arthropasty.

Approach	Indications	Outcomes	References
Medial parapatellar approach [11,12]	Work horse exposure for total knee revision procedures. Variations include Insall modification where the patellar retinaculum is peeled off the medial third of the patella in a subperiosteal fashion. The Von-Langenbeck modification takes the proximal part of the incision through the fibers of the vastus medialis although this can cause interruption in the pull of the vastus medialis leading to subluxation of the patella laterally.		
Subvastus approach [13]	Not recommended in revision scenarios as it is difficult to mobilize the patella without compromising the patellar tendon insertion.	This approach is not used for revision total knee arthroplasty. For primary total knee arthroplasty, it has showed promising results in early postoperative functional outcomes compared to medial parapatellar arthrotomy.	
Lateral parapatellar approach [14]	Used in setting of previous lateral patellar arthrotomy to maintain blood supply to the patella bone itself. This is difficult at times to mobilize the patella medially in the revision setting with this approach.	Potentially useful in severe fixed valgus deformities. Studies have shown equivalent outcomes when compared to medial parapatellar approach in valgus knees. Studies are limited in revision arthroplasty.	
Quadricep Snip [15,16]	Division of the quadricep tendon at the proximal end in a superolateral direction. Main benefit is that if done correctly does not require modification of postoperative protocols. Best used in revision settings where exposure is difficult, and relief of the extensor mechanism is needed.	No difference in extensor mechanism function and functional outcomes when compared to medial parapatellar approach.	
V-Y Quadricepsplasty (Turndown) [17–19]	Used in settings of major arthrofibrosis due to quadricep contracture. Historical in nature. Very rarely used. This is an extension of the medial parapatellar arthrotomy. The extensor mechanism is divided in a distal lateral direction at the proximal end of the medial parapatellar arthrotomy. The dissection is taken distally through the tendinous insertion of the vastus lateralis and the lateral retinaculum, allowing the extensor mechanism to turn down and aid in exposure.	Approach requires postoperative rehabilitation modification to allow extensor mechanism healing. There is risk of superolateral genicular artery disruption and patellar fragmentation as well as increased active extension weakness and extensor lag.	
Tibial Tubercle Osteotomy [20–22]	Done for both exposure and prosthesis extraction purposes. Roughly 7 cm in length and 1 cm thick osteotomy maintaining the lateral periosteal sleeve and anterior compartment muscular attachments to the tibial tubercle. The extensor mechanism soft tissue structures stay attached to the tibial tubercle.	Reports note that postoperatively rehabilitation can proceed as normal. Patients can range the knee and weight bear as tolerated. This approach allows exposure without disrupting the proximal extensor mechanism and relies on either screw or wire fixation as opposed to suture fixation in contrast to a V-Y turndown or quadricep snip. Risks are tibial fracture through distal pole of osteotomy, extensor lag due to delayed union or loss of fixation and proximal migration of osteotomy, as well as symptomatic nonunion.	
Banana Peel [23]	The patella tendon is peeled off the anterior tibia. This is done as much as necessary without going beyond the lateral and distal extent of the patellar tendon attachment to the tubercle, which allows the extensor mechanism to maintain its integrity. This technique allows for almost complete peel of the patellar tendon off the anterior tibia.	In a report of 98 knees all knees showed active extension without lag at an average of 39 months. Risks are that you are doing a controlled avulsion of the patellar tendon off the anterior tibia which is disconcerting as surgeons normally do everything they can to preserve the attachment of the patellar tendon during revision surgery.	
Medial Epicondylar Osteotomy [24,25]	4 × 1 cm thick wafer of medial epicondyle is osteotomized off the femur while keeping all soft tissue attachments including the medial collateral ligament attached.	Outcome reports are limited. However, this technique has been described in primary total knee arthroplasty for fixed varus deformities as well as in revision settings for arthrofibrosis and conversion from knee arthrodesis to total knee arthroplasty.	

Conclusions

There are a variety of approaches that can be used for a revision TKA. Each with a specific advantage, indication, and risk. All of these approaches can be utilized using the incision principles described here (Table 1). However, the blood supply to the anterior aspect of the knee must be understood and respected by a total knee surgeon. Whenever a lateral incision is encountered before TKA, the lateral incision should be used, raising a medially based full-thickness subfascial flap to prevent catastrophic wound breakdown. Failure to do so risks skin necrosis between the two incisions, leading to periprosthetic joint infection and the need for gastrocnemius muscle flap reconstruction.

CRediT authorship contribution statement

Malcolm E. Dombrowski: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Taylor M. Rowe:** Writing – review & editing, Writing – original draft, Project administration, Methodology. **Thomas K. Fehring:** Writing – review & editing, Writing – original draft, Supervision, Methodology.

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