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15-Year Experience With Soft Tissue Expansion in Total Knee Arthroplasty

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Abstract: Preoperative identification of a knee at risk for wound healing after total knee arthroplasty (TKA) allows the surgeon to apply a soft tissue expansion technique to expand the available tissue for closure and healing after TKA. A consecutive series of 64 soft tissue expansions were performed for 59 cases of conflicting incisions and 5 cases of severe angular deformity, with a mean of 3.5 previous surgeries. An average 2.1 expanders were used for a total volume of 359 mL. Expansion took a mean of 70 days during which 14 minor and 7 major complications occurred. There were 8 post-TKA complications, 5 of which required a return to the operating room. Soft tissue expansion is a safe, prophylactic technique that provides adequate coverage in this complex subset of patients. **Keywords:** TKA, wound healing, soft tissue expansion.

Soft tissue breakdown can compromise a well-performed total knee arthroplasty (TKA). Soft tissue expansion (STE) techniques are indicated when insufficient or inadequate soft tissue coverage is present for successful wound healing. Multiple, conflicting incisions (Fig. 1), previous skin graft or flap application, significant angular and/or rotational deformities, and procedures requiring expanded soft tissue coverage (eg, extensor mechanism allograft) may be treated with an expansion technique. Eight to 12 weeks must be allocated for STE, depending on the magnitude of the planned expansion.

Materials and Methods

There was no external funding source for this study. Institutional review board approval was obtained for this study.

Patient selection was based on subjective criteria, which began with a history and physical examination of the affected extremity. In all cases where concern regarding soft tissue healing potential existed, a referral was made to a plastic surgeon who then made the final decision regarding the need for expansion. A single plastic surgeon made all determinations as to whether an STE technique was appropriate vs a more advanced soft tissue transfer or flap. In cases that lack a safe soft tissue plane for expansion, such as irradiated tissue or thin split thickness skin grafts applied directly over proximal tibial bone, an alternative technique was selected. A control group was not included for obvious ethical reasons.

STE Protocol

This STE protocol has been previously published in detail [1-4]. An outline of the current technique is included.

At the time of expander insertion, the patient is placed in a supine position on the operating table. Prophylactic antibiotics are given, and a tourniquet is applied but not inflated. The entire lower extremity is prepared and draped in a similar sterile fashion to the planned reconstructive procedure. All previous incisions are marked, and a planned incision line for the reconstructive procedure is drawn on the knee (Fig. 2).

A mix of dilute local anaesthetic is prepared and infiltrated subcutaneously in the area of the planned expansion until the subcutaneous tissue and skin blanch, typically allowing 250 to 300 mL to be injected. A Tuohy needle, with a blunt tip and an opening at 90° to the long axis of the shaft, is used. Fluid opens the soft tissue plane ahead of the advancing blunt tip needle.

Insertion of the expanders is performed through a 2- to 4-cm incision at the superior aspect of the planned incision for later reconstruction. This access incision

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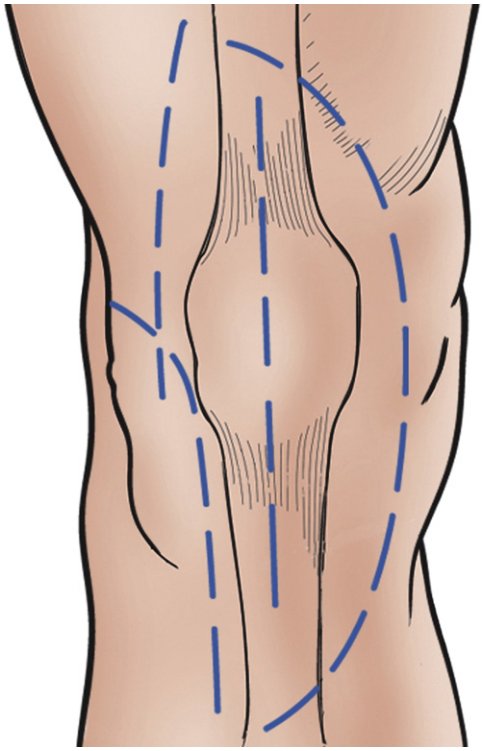

Fig. 1. A knee with multiple conflicting incisions.

must not fall into the area of expansion. A subcutaneous pocket is created using blunt and scissor dissection in the areolar plane between the subcutaneous fat and the musculotendinous and patellar layer. Multiple length tenotomy scissors are useful for dissection. A dilute antibiotic solution is then used to irrigate the pocket followed by sustained pressure over the area to achieve hemostasis. In rare cases, a scope or fiberoptic retractor and insulated forceps are used to localize and cauterize bleeders, thus achieving a dry plane.

Fig. 2. A knee before expansion with the planned pocket for expansion, and modified TKA incisions marked.

Rectangular expanders up to 350 mL in volume are then inserted. The amount of expanded tissue produced is proportional to the projection of the expander. Typically, 2 expanders are placed at right angles to each other. One to 4 expanders can be used, depending on the size of the extremity, ability of the soft tissues to accommodate the expanders, and the size of the soft tissue flap required. Care must be taken to avoid folds or creases in the expanders because this can cause increased local pressure on the soft tissues, particularly in the subcutaneous plane. The injection ports are secured on either side of the insertion site, superior to the expanders, decreasing the tendency for fluid to drain out through the injection sites. Expanders are then inflated until all of the dead space is taken up. The knee is wrapped in a bulky dressing and Ace wrap, placed in a knee immobilizer and elevated on pillows.

The patient is admitted overnight for observation. A knee immobilizer is worn for the first week, and no expansion is performed during this time period. The patient is allowed to weight-bear as tolerated but is encouraged to keep the extremity elevated at rest.

Gradual expansion is begun 1 week later, at a rate of 10% of the expander volume per week. Two factors limit the rate of expansion: the capillary refill in the overlying skin should not exceed 5 seconds, and the patient must be able to comfortably tolerate the rate of expansion. Range of motion is not restricted during the expansion process.

At the time of surgery, the soft tissue envelope and previously planned incision line are reassessed (Figs. 3 and 4). The soft tissue expanders are easily removed from the subcutaneous pocket. Care is taken not to violate the reflected margins of the pocket because these are important in blood supply to the soft tissue flaps. Any further dissection for exposure must be made in a full-thickness, subperiosteal manner.

At the completion of the surgery and after the closure of the arthrotomy, the soft tissue envelope is reexamined. There is often excess skin and soft tissue for closure (Fig. 5). In most cases, this can be closed primarily without removing any of this expanded tissue. In selected cases, broad incisions and small intervening skin planes between parallel incisions may be excised.

Meticulous hemostasis is obtained, and subcutaneous drains are placed medially and laterally in the subcutaneous pocket. The tourniquet is released, and the soft tissue flaps are examined for viability and perfusion before closure. The pseudocapsule is closed as a separate

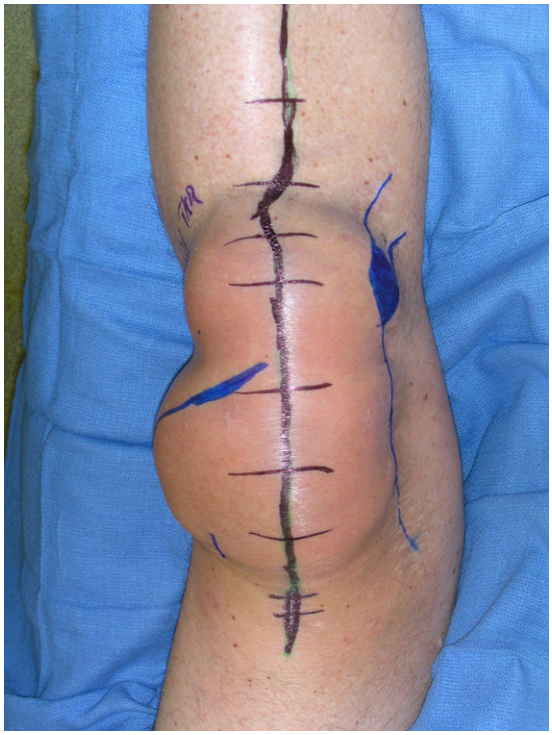

Fig. 3. A knee at the completion of the expansion process before TKA.

layer, followed by an interrupted subcutaneous layer and staples. A compressive dressing is applied, and the extremity is elevated on pillows.

Fig. 4. A completed expansion with the initial TKA incision.

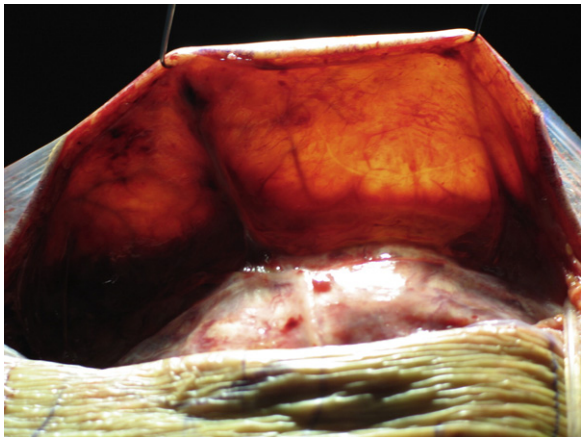

Fig. 5. A healthy, well-vascularized soft tissue envelope at the completion of a TKA.

Subcutaneous drains decrease the rate of hematoma formation in the pocket created. They are removed when output decreases to below 20 mL per shift or 40 mL per day, typically about the 48-hour mark from surgery. Until then, the patient is restricted to bed rest with the extremity elevated and foot pumps. Low-molecular-weight heparin is held until the subcutaneous drains are removed.

Continuous passive motion is gradually initiated after drain removal, and the patient is allowed to begin mobilizing weight-bearing as tolerated the next day. It is

Fig. 6. A healed modified incision after STE and TKA. Note the previous conflicting incisions.

important to maintain a compressive dressing over the incision and to elevate the extremity while at rest.

Results

Sixty-two patients underwent 64 STEs from 1992 through 2006 (Fig. 6). Demographics included 30 women and 32 men; 33 right, 27 left, and 2 bilateral surgeries; and an average age of 54 years (range, 27-87 years). Preoperative diagnoses necessitating this protocol were as follows: 5 cases of severe angular deformity (Table 1) and 59 cases of multiple conflicting incisions (Table 2). The average number of previous surgeries on the respective knee was 3.5. The average number of expanders used was 2.1 (range, 1-5), an average total volume of 359 mL (range, 95-1522 mL) was injected. The expansion process took a mean of 70 days to complete (range, 36-174 days).

With respect to complications, cases that required local care, antibiotics, or removal of fluid from one of the expanders were considered minor complications. There were 14 minor complications (22%) during the expansion phase. The specific diagnoses and treatments are listed in Table 3. None of these complications resulted in abandonment of the planned arthroplasty, nor did they require operative intervention.

Major complications were defined as those requiring a return to the operating room. There were 7 major complications (11%) that required reoperation, detailed in Table 4. All cases but 1 went on to TKA. In this particular case, early in the series, STE was attempted after radiation therapy and split thickness skin grafting over the knee and proximal tibia. In this case, there was no healthy plane for soft tissue dissection. Expansion resulted in soft tissue necrosis and abandonment of the expansion protocol. This case did not go on to TKA. We no longer advocate STE in cases with radiated, inexpansible tissue. More invasive soft tissue transfers are necessary to transport a healthy bed of tissue for healing in these cases.

After TKA, 6 early complications occurred before the use of subcutaneous drains. There were 3 cases of prolonged wound drainage. Treatment involved holding motion and local care. Three cases of wound hematomas occurred in the subcutaneous plane. These cases required a return to the operating room for washout and closure. There were no late complications in these cases. After this experience, we began placing subcutaneous drains. There were no subsequent cases of prolonged drainage or deep hematomas.

Table 1. Severe Angular Deformities

Significant fixed varus deformity after multiple fractures and bowing associated with osteogenesis imperfecta
Marked fixed varus deformity >25°
Posttraumatic postsurgical significant scarring and varus deformity
Marked fixed varus deformity >30° and previous open arthrotomy
26° fixed varus deformity

Table 2. Multiple Conflicting Incisions and Scarring (Note Some Patients Included In Multiple Groups)

No.	Diagnosis
27	Hardware fixation for fracture or osteotomy
23	Open meniscectomies or cartilage procedures
15	Previous open ligament procedures
12	Prior infection
8	After TKA (3 extensor mechanism ruptures, 5 infections)

There were 2 early wound healing complications after TKA. In the first case, there was localized skin breakdown at 2 months over the proximal tibia, along the inferior aspect of the incision. This was successfully treated with debridement and primary closure. The second case occurred in a smoker and involved blistering and superficial epidermolysis at 1 month postoperatively. This case was successfully addressed with local full-thickness soft tissue advancement flap and primary closure. There were no further complications in these cases.

Discussion

This report is a comprehensive review of a 15-year experience with STE. It represents by far the largest reported series with this technique before TKA, to the best of our knowledge. Earlier reports include those by Gold et al [1] and Manifold et al [2]. Patients from both of these studies were included in this current report. The latter study reported on the first 27 patients with 29 knees treated with STE.

A number of important observations and modifications have been performed over the 15-year period. The first concerns patient selection, as noted in the "Results" section. We no longer perform this procedure on patients who lack a healthy plane for expansion. Cases

Table 3. Minor Complications During STE

Diagnosis	Treatment
Blister	Antibiotic ointment
Blister	Antibiotic ointment
Blister	Antibiotic ointment
Blister	Oral antibiotics
Wound breakdown	Antibiotic ointment
Erythema	Antibiotic ointment
Erythema	Antibiotic ointment
Erythema	Oral antibiotics
Erythema	Oral antibiotics
Erythema	Oral antibiotics
Erythema	Oral antibiotics
Pain and shift in superior expander	Decrease 20 mL in volume; oral antibiotics
Skin breakdown laterally	Decrease 42 mL in volume; immobilizer; oral antibiotics
Erythema, leak medial expander	Intravenous antibiotics

Table 4. Major Complications During STE

Diagnosis	Treatment	Result
Presumed displacement of expander	Intraoperatively found to be not displaced	TKA
Infection over 1 of 4 expanders	Debridement and revision of lateral expander	TKA
Erythema and swelling over expanders	Expander removal and 3 weeks of intravenous antibiotics	TKA
Swelling, rule out hematoma	Exploration negative for hematoma, cultures negative	TKA
Infection and skin breakdown over 1 expander	Debridement, removal of lateral expander, and closure	TKA
Migration of tissue expanders	Expanders revised	TKA
Cellulitis, eschar formation, full-thickness soft tissue loss over expander	Removal of expanders, debridement, and split thickness skin grafting	This case did not go on to expansion.

involving irradiated or skin grafted tissue that is densely adherent to bone require more advanced soft tissue transfer procedures.

After reconstruction, subcutaneous drains are placed in the plane previously occupied by the expanders, and low-molecular-weight heparin is held until these drains are removed. Before these modifications, wound complications, consisting of hematoma formation and persistent drainage, occurred after 6 TKAs. There were no further complications after these 6 arthroplasty procedures.

Although patients are encouraged to mobilize during this process, they are certainly less active than during regular day-to-day activity. Thus, due to the limited mobility of the extremity during the expansion period and the delay in initiating anticoagulation after surgery, a history of deep vein thrombosis is a relative contraindication to this technique.

Referral to a plastic surgeon was performed in any and all cases where concern regarding soft tissue healing after TKA existed. The decision to proceed with expansion vs utilization of a flap or other soft tissue procedures was made by the plastic surgeon. This clinical determination was primarily based on the existence of a healthy plane of tissue for insertion and expansion. The length of time required for expansion was based on the size of the defect and the patient and soft tissue's ability to tolerate expansion and averaged 70 days.

There are a number of limitations to our study. The retrospective nature and lack of comparison group make it difficult to compare STE with other soft tissue management options. The scope of this study, which describes the technique, complications, and outcomes related to the expansion process, does not include long-term outcome scores for the ensuing TKA.

Reports from other centers with STE are limited. The technique was first described [5] and subsequently applied to lower extremity reconstruction by Manders et al [6]. It has since seen wider applications. In the knee literature, they include the use of an expansion protocol in selected cases for revising arthrodesed knees to total knees [7,8] and in 2 staged revisions for infection [9]. Other reports in the orthopedic literature include successful pediatric applications in the treatment of clubfoot [10-12] and equinovarus deformities [13] with associated soft tissue contractures. Expanders have also been used to address soft tissue deficiencies in the upper extremity, after trauma and burns, before reconstruction [14]. Endoscopic placement of soft tissue expanders enabled Sharobaro et al [15] to reduce their rate of complications and the length of time for expansion.

Patients with multiple conflicting incisions or severe angular deformities comprise a complex subset of patients with TKA. Soft tissue expansion is an effective prophylactic prearthroplasty option to reduce the risk of a wound healing complication after TKA. We continue to use this protocol when concern regarding wound healing potential exists.

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