McCraw and Arnold's Atlas of Muscle and Musculocutaneous Flaps

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Interplast
Healing Bodies, Changing Lives

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Publication

GRACILIS

ANATOMICAL CONSIDERATIONS

Surface Markings

The cutaneous segment of the gracilis myocutaneous flap measures approximately six by twenty-four centimeters. It is centered on an imaginary line which passes between the pubic tubercle proximally and the semitendenosus tendon distally. The proximal gracilis muscle is difficult to palpate, but it can be identified adjacent to the fascial cleft which lies directly behind the prominent tendon of the adductor longus muscle. The distal tendon of the semitendinosus muscle, which lies between the gracilis and semimembranosus tendons, is easily palpated above the knee.

Origin and Insertion

The gracilis muscle originates from the pubic tubercle and the inferior ramus of the pubis and inserts into the pes anserinus at the medial knee. It functions as an accessory thigh adductor and knee flexor and is a totally expendable muscle.

Adjacent Muscles

The sartorius muscle lies anterior to the gracilis muscle, and the semimembranosus and semitendinosus muscles lie posterior to it in the distal thigh. In the upper thigh the adductor magnus muscle lies deep to the gracilis muscle and the adductor longus lies directly anterior to the gracilis throughout its course. The adductor longus muscle is the most important palpable landmark because its prominent proximal tendon forms a notable "cleft" with the gracilis muscle when the hip is forcibly adducted with the patient in the "frog leg" (externally rotated) position.

Vascular Pattern

The gracilis muscle has a proximal, dominant pedicle from the produnda femoris artery which enters the muscle approximately nine to ten centimeters below the inguinal ligament. The proximal vessels may enter the muscle as low as fifteen centimeters below the inguinal ligament. This can make the flap unusable. When a low proximal vessel is encountered in raising a gracilis flap, the opposite muscle should be explored since the vascular arrangement is not always symmetrical. There is usually a small vessel in the midpoint of the muscle which is inconsequential. A branch from the saphenous artery is the dominant blood supply to the distal one-third of the muscle and its overlying skin. As is the case in most long, thin muscles, the intramuscular collateralization and crossover between the proximal and distal vasculature is minimal. Nevertheless, the entire gracilis muscle can be safely transposed on the proximal vessels as an "island" muscle flap.

Motor Nerve

Femoral nerve.

Sensory Nerve

Medial cutaneous nerve of the thigh.

USES

The gracilis myocutaneous flap is used primarily for perineal defects including vaginal, scrotal, and penile reconstructions. It is still the myocutaneous flap of choice for a total vaginal reconstruction or for the abdominoperineal defect. The flap also has some application in coverage of the medial two-thirds of the groin and in problems of the suprapubic area. It has occasionally been used for ischial pressure sores in paraplegics when the paralysis is "spastic" in nature and a reasonable amount of muscle bulk is preserved. If the paralysis is flaccid, the results with the denervated gracilis myocutaneous flap have been quite disappointing.

The gracilis muscle alone is an excellent "free" muscle flap for distal tibial osteomyelitis because of its long and narrow configuration. It is also quite useful for the vascularization of a neourethral full-thickness skin graft or as an interposition muscle flap for the correction of vesicovaginal or rectovaginal fistulae. Bilateral, crossed gracilis muscle flaps have been used for anal incontinence even though this provides an unphysiologic replacement for the sophisticated anal sphincter mechanism.

The primary criticism of the gracilis myocutaneous flap is that its viability in the distal third of the flap is variable. One must accept the fact that the cutaneous segment which can predictably be carried will not extend into the distal third of the thigh without a "delay." This same criticism does not apply to the muscle flap, which will survive entirely on the proximal vessels. If the gracilis myocutaneous flap is properly designed and carefully handled, it is a very reliable flap.

REGIONAL FLAP COMPARISONS

For surface defects of the central perineum the gracilis myocutaneous flap is compared primarily to the inferior gluteal fasciocutaneous flap, which is quite reliable, sensate, and technically undemanding to elevate. Although the fasciocutaneous flap provides excellent surface cover,

bilateral gracilis myocutaneous flaps are more useful for major internal pelvic defects because of their size and bulk. Very large central perineal surface defects can also be corrected by the very reliable inferiorly based rectus abdominis myocutaneous flap, but it has the disadvantage of significant donor site morbidity. Neither the TFL flap nor the rectus femoris myocutaneous flap reaches the central perineum or the pelvis because of the limited arcs of rotation in this direction.

Even though bilateral gracilis myocutaneous flaps are usually employed for pelvic exenteration defects, the inferiorly based lower horizontal rectus abdominis myocutaneous flap can be used for these same defects. The rectus abdominis flap is more applicable to high pelvic defects because of its proximity, and it is by far the largest myocutaneous flap which will reach into the pelvis. If a laparotomy is anticipated, the inferiorly based rectus abdominis myocutaneous flap immediately becomes a reasonable alternative for major pelvic defects.

The gracilis myocutaneous flap is seldom considered for the usual ischial pressure sore because of the unpredictable survivability of the denervated gracilis myocutaneous flap. This is true even in the spastic paraplegic. The V-Y biceps femoris myocutaneous flap is considered to be a more reliable method of reconstruction in these individuals.

DISADVANTAGES

Vascular "spasm" poses the biggest threat to the gracilis myocutaneous flap because once it exists it is practically impossible to relieve. Significant vascular "spasm" will usually cause some loss of the cutaneous segment, but not of the muscle. Gentle dissection and avoidance of any stretch of the vessels are the most important measures for the prevention of "spasm."

Occasionally the dominant pedicle of the gracilis muscle may not lie as proximal as we would like. If the proximal pedicle falls fifteen centimeters or more below the inguinal ligament, the constricted arc of rotation can make the flap unusable. Some upward mobility can be gained by skeletonizing the dominant pedicle and dividing the intermuscular septum. The vasculature of the opposite gracilis muscle should be explored as the next option since it may have a completely normal vascular arrangement. The inferior gluteal fasciocutaneous flap can still be used even though a gracilis myocutaneous flap has been elevated in the same leg. Prior elevation and return of a gracilis myocutaneous flap does not harm the viability of the adjacent fasciocutaneous flap, and the donor site in the thigh can still be primarily closed.

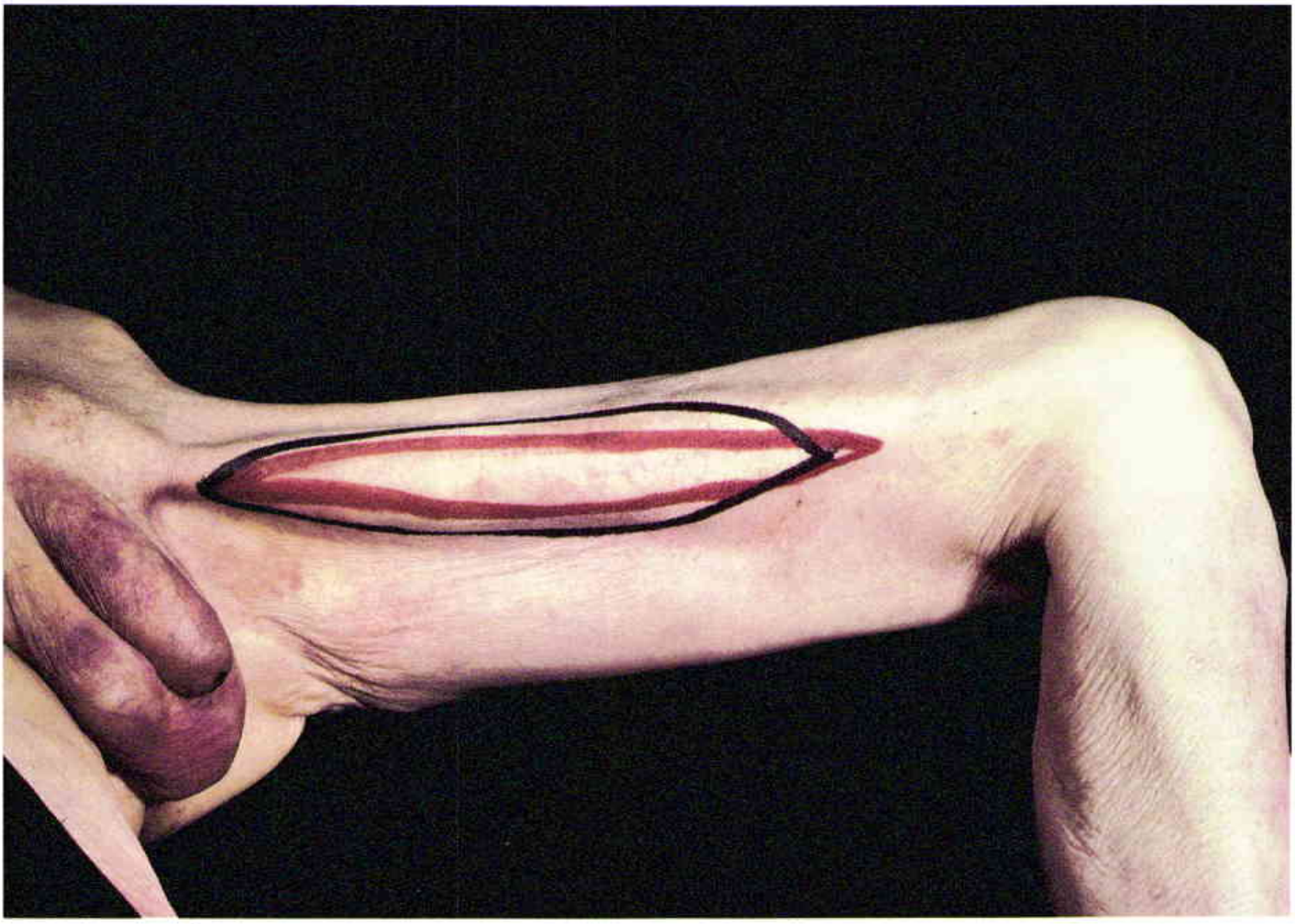
ADVANTAGES

The gracilis myocutaneous flap is very useful for most perineal reconstructions even in the context of the reliable inferior gluteal fasciocutaneous flap. The gracilis myocutaneous flap has the advantage of providing muscle, skin, and bulk. It will reach a higher point in the pelvic cavity than any adjacent flap, except the inferiorly based rectus abdominis myocutaneous flap, which can be passed directly into the pelvis through the lower posterior rectus sheath. The gracilis myocutaneous flap can be used without harm to the other adjacent flaps of the thigh, and the donor site is inconsequential.

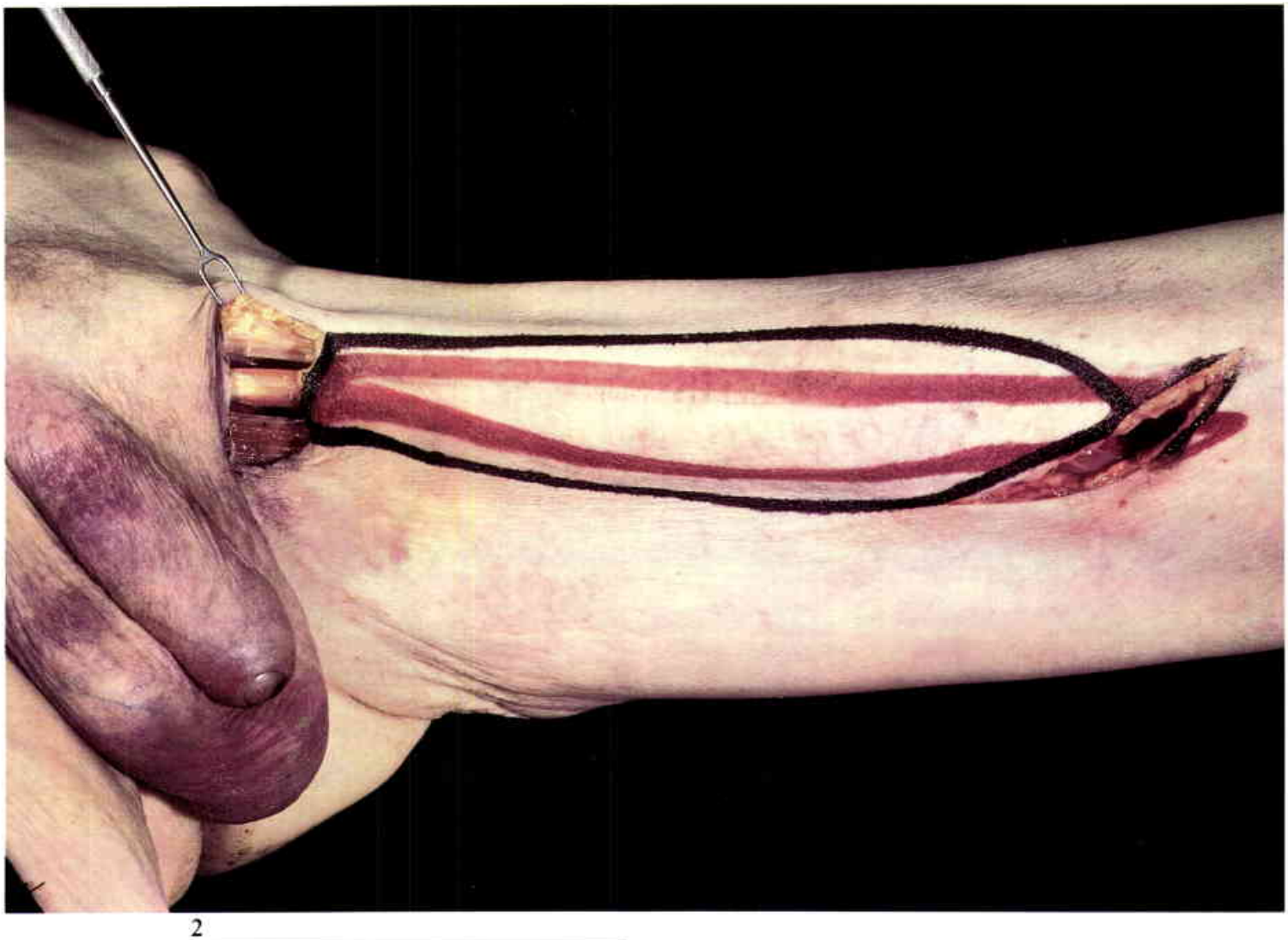
COMPLICATIONS, PITFALLS, AND DONOR SITE

The "island" gracilis myocutaneous flap must be respected for its intolerance to vascular "spasm." This is usually caused by undue torsion or tension on the flap vessels, and the lethality of this event is difficult to reverse. The improper placement of the cutaneous segment is another preventable surgical error. The gracilis muscle will only "carry" skin which directly overlies the muscle so the course of the muscle should be identified proximally and distally before a commitment is made determining the eventual location of the skin "island." The usual skin "island" measures six by twenty-four centimeters and does not include the skin overlying the distal one-third of the muscle. This distal skin is independently supplied by branches of the saphenous artery. It must be "delayed" in order to ensure its viability.

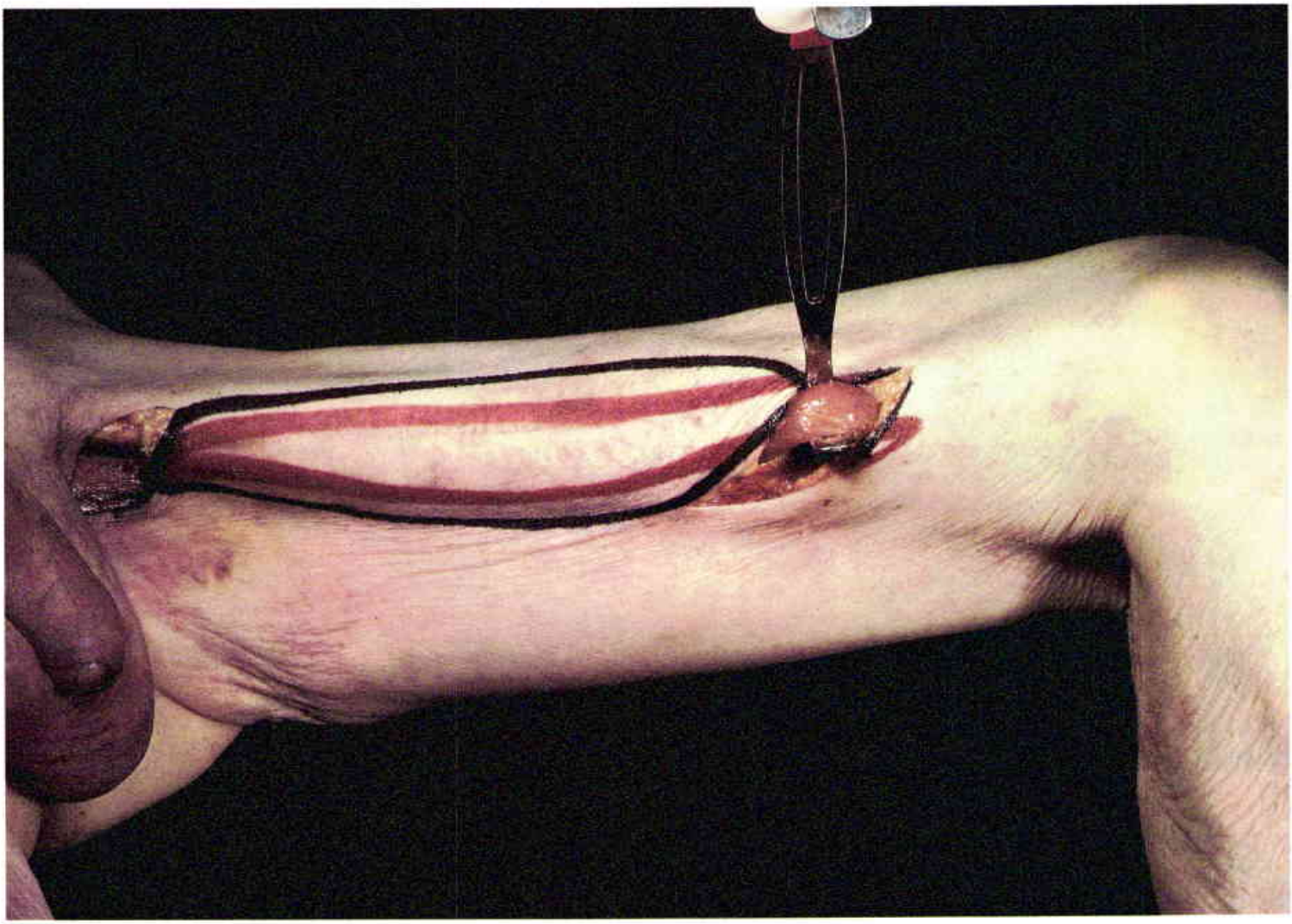
The donor site should be trouble free if it is carefully closed and adequately drained. Retention sutures of #2 nylon tied over 4 × 4 bolsters offer a secure closure of the deep layers and allow us to avoid buried sutures. The large nylon sutures should be removed by the fourth or fifth day to prevent permanent epithelialization of these sizable suture tracts. There is no functional loss from the sacrifice of the gracilis muscle, and its use does not compromise the later use of the other adjacent myocutaneous and fasciocutaneous flaps in the thigh.



1
The leg is abducted to outline the gracilis muscle in red and the overlying cutaneous segment in black.



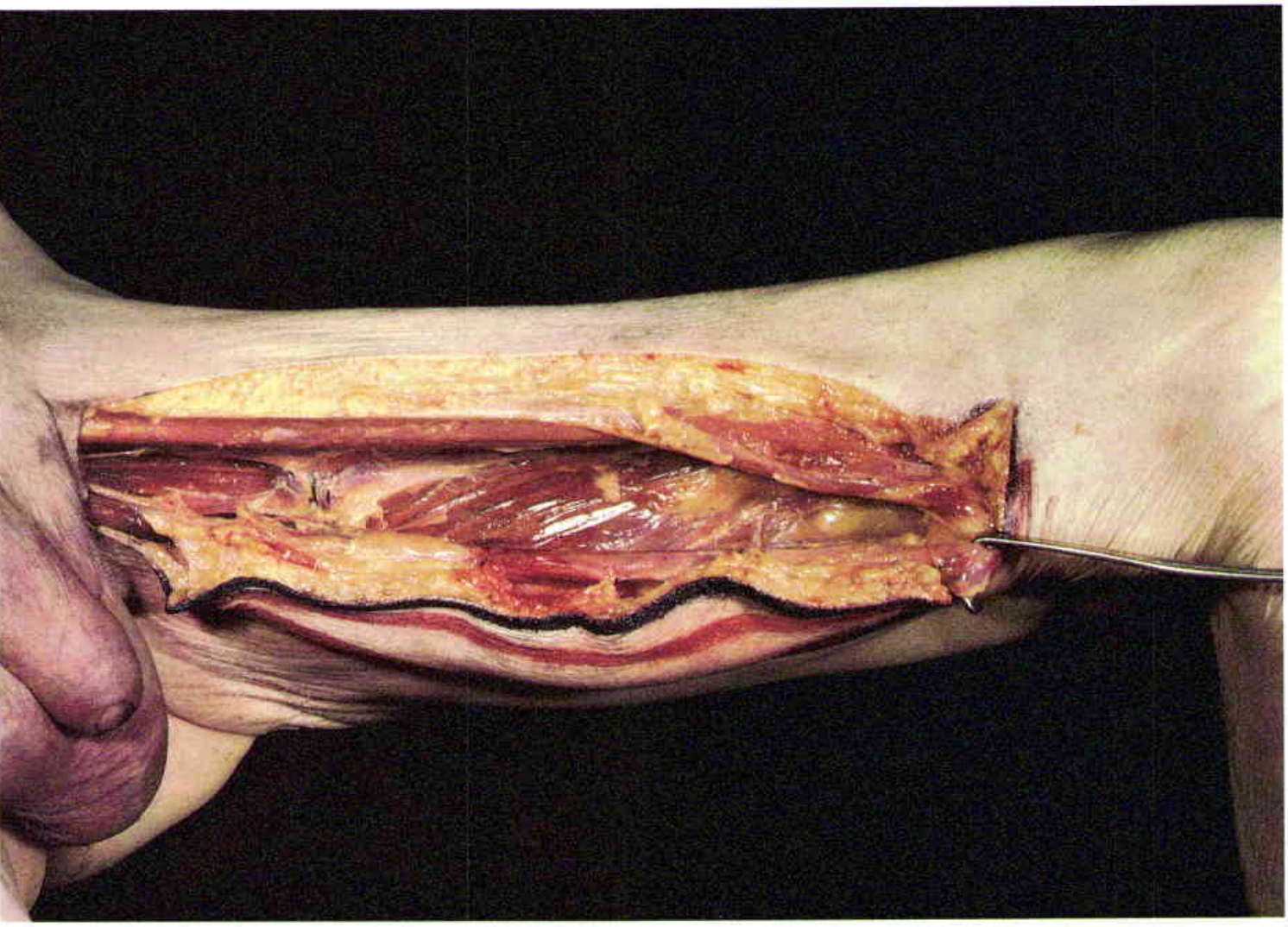
2
The proximal gracilis tendon is isolated. The hook retracts the adductor longus tendon. The distal incision is used to confirm the course of the gracilis muscle.



3

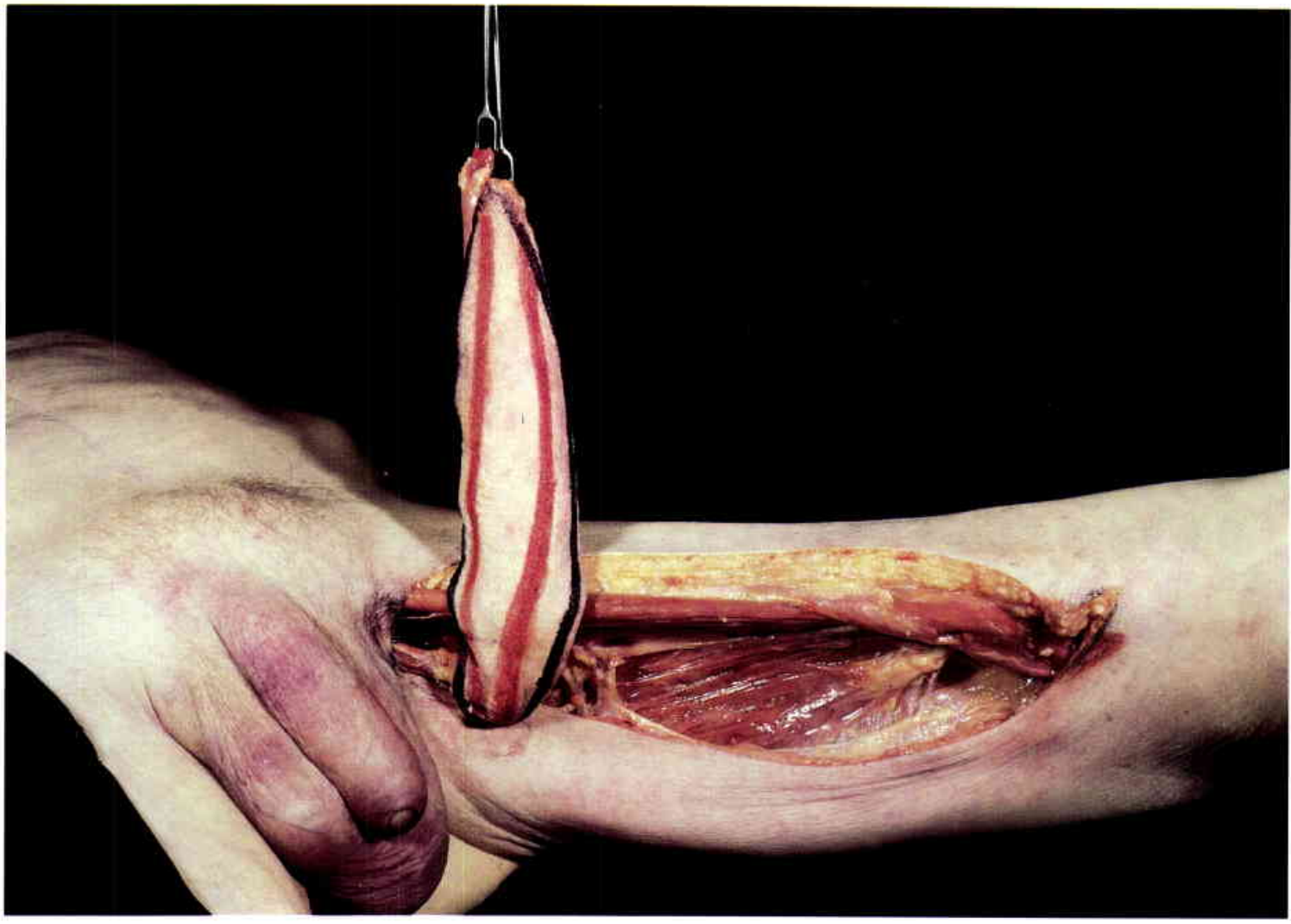
The distal gracilis muscle is identified between the semitendinosus tendon posteriorly and the sartorius muscle anteriorly. By "bow stringing" the gracilis muscle with a retractor, the proper location of the overlying skin can be demonstrated.

4
The dissection is continued anteriorly and posteriorly until the surrounding muscles are identified. The sartorius muscle is seen passing obliquely over the retracted gracilis muscle. In the proximal wound the adductor longus muscle lies just anterior to the gracilis myocutaneous unit.



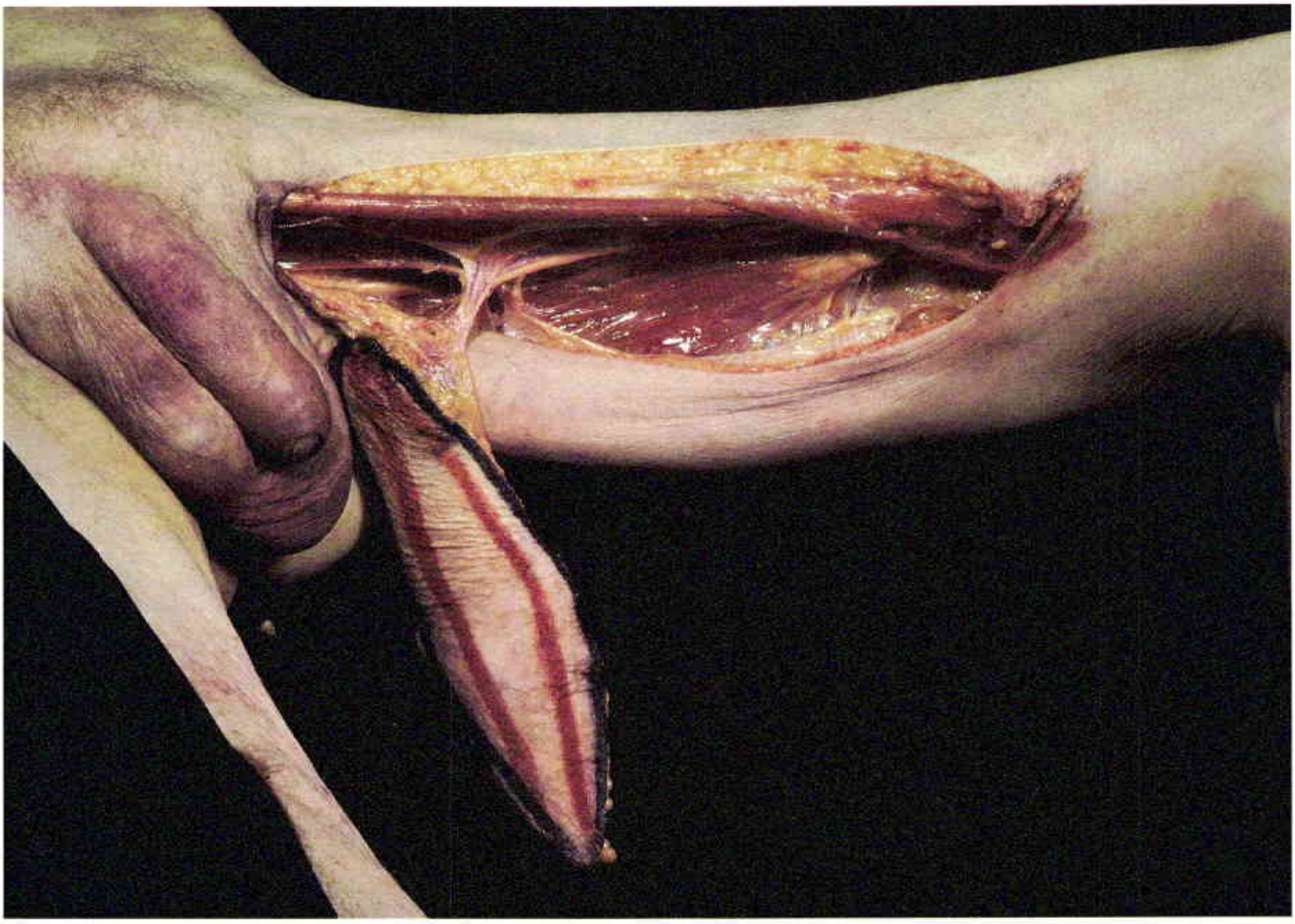
5

The sartorius muscle is visualized in the anterior portion of the distal wound. The oblique fibers of the adductor magnus muscle are seen to pass perpendicularly to the sartorius muscle in a broad expanse. The fascial covering of the adductor longus muscle is then elevated away from the gracilis muscle anteriorly until the primary vessels are identified. The dominant vessels to the gracilis muscle pass between the adductor longus and the adductor brevis muscles just anterior to the adductor magnus muscle. The posterior dissection of the gracilis muscle can be completed promptly once the primary vessels are identified because there are no structures of significance in this area. The dominant vessels are seen entering the proximal one third of the gracilis muscle in the cleft between the adductor longus and magnus muscles.



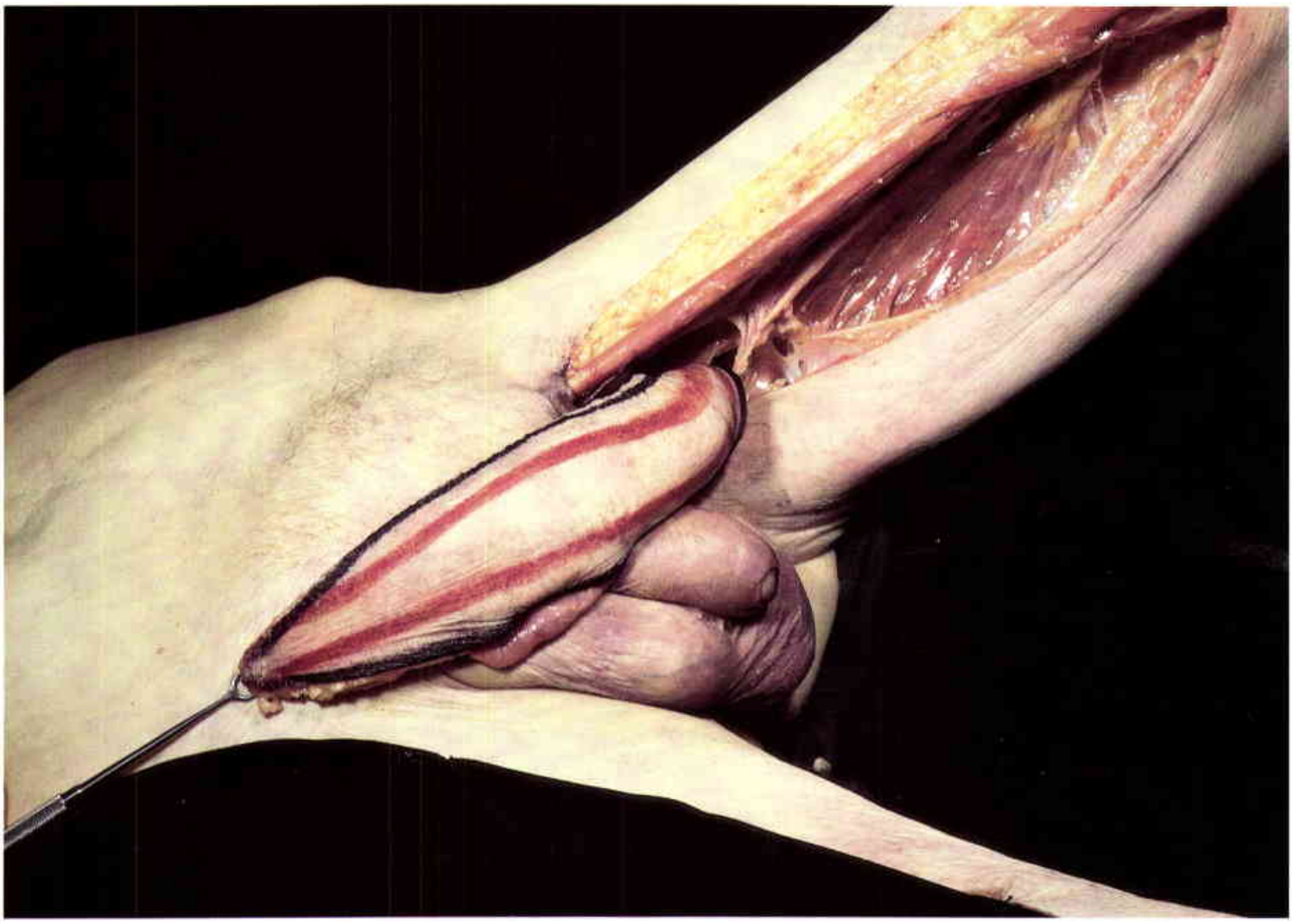
6

The gracilis myocutaneous flap is elevated on the proximal vessels as an "island" flap measuring six by twenty-four centimeters. To improve upward mobility, it is helpful to divide the fascia which overlies the proximal muscle. It is not helpful to divide the muscular origin to enhance the upward mobility of either the gracilis muscle or the musculocutaneous flap.

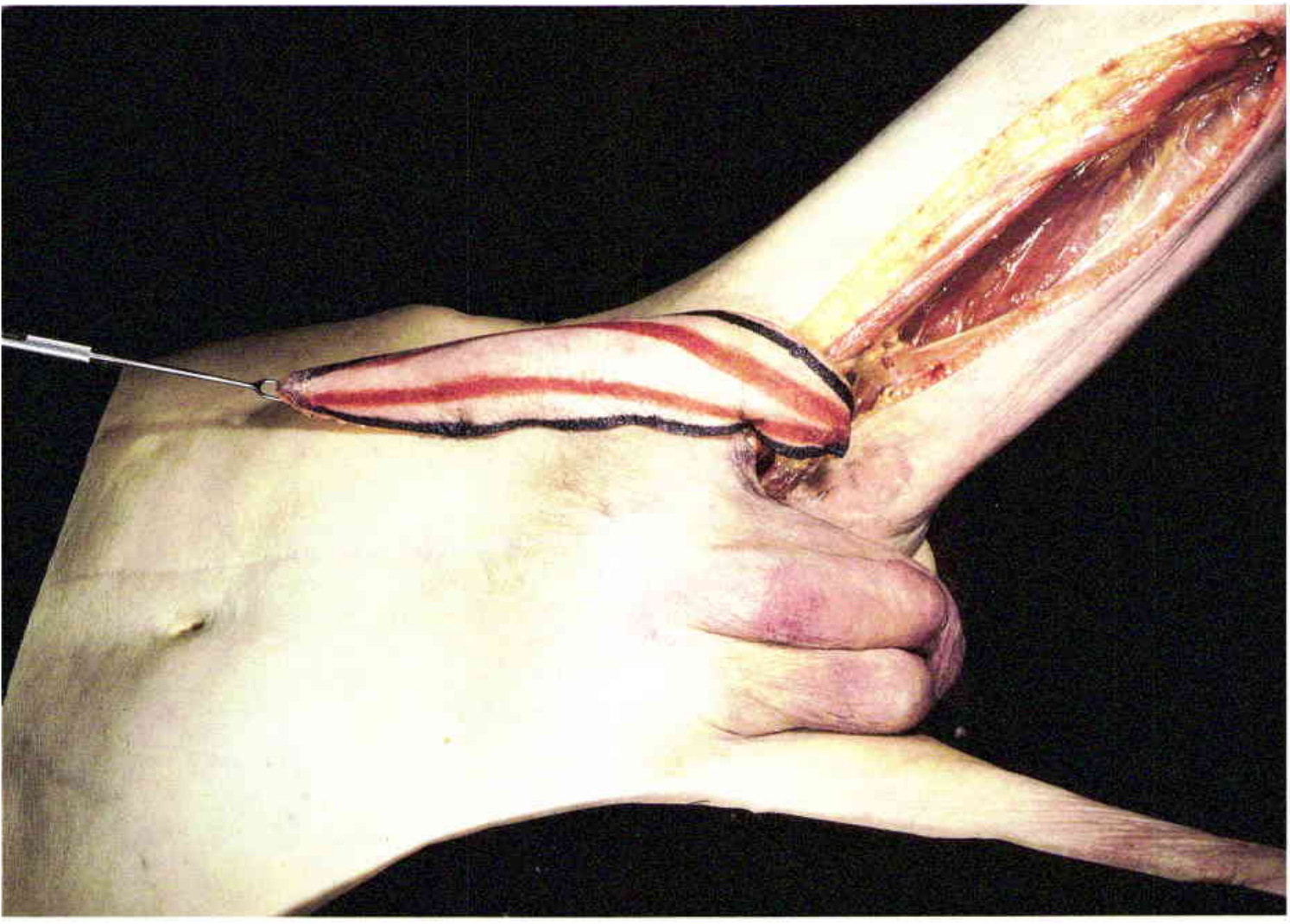


7

The posterior flap excursion is demonstrated by placing the flap on a flat surface. The flap will easily reach the ischium and the posterior perineum. This type of stretch on the dominant vascular pedicle should always be avoided because it is the "ideal method" to cause vascular spasm and partial flap necrosis.

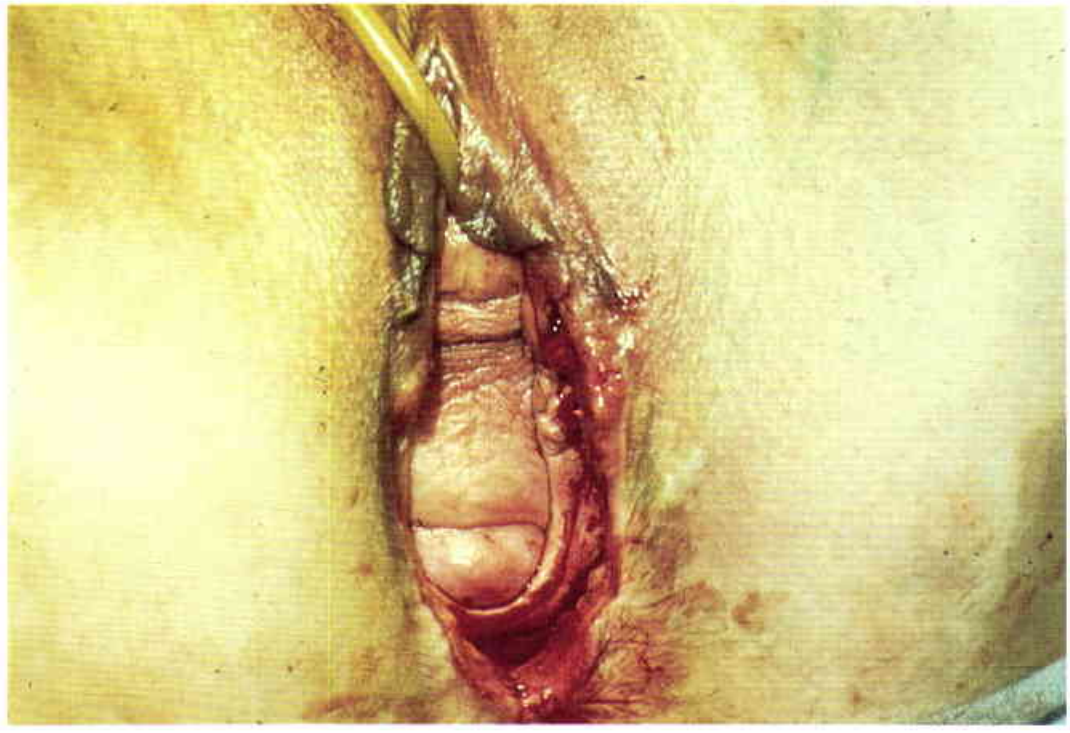


8
The "island" flap will reach the suprapubic area and the central perineum.



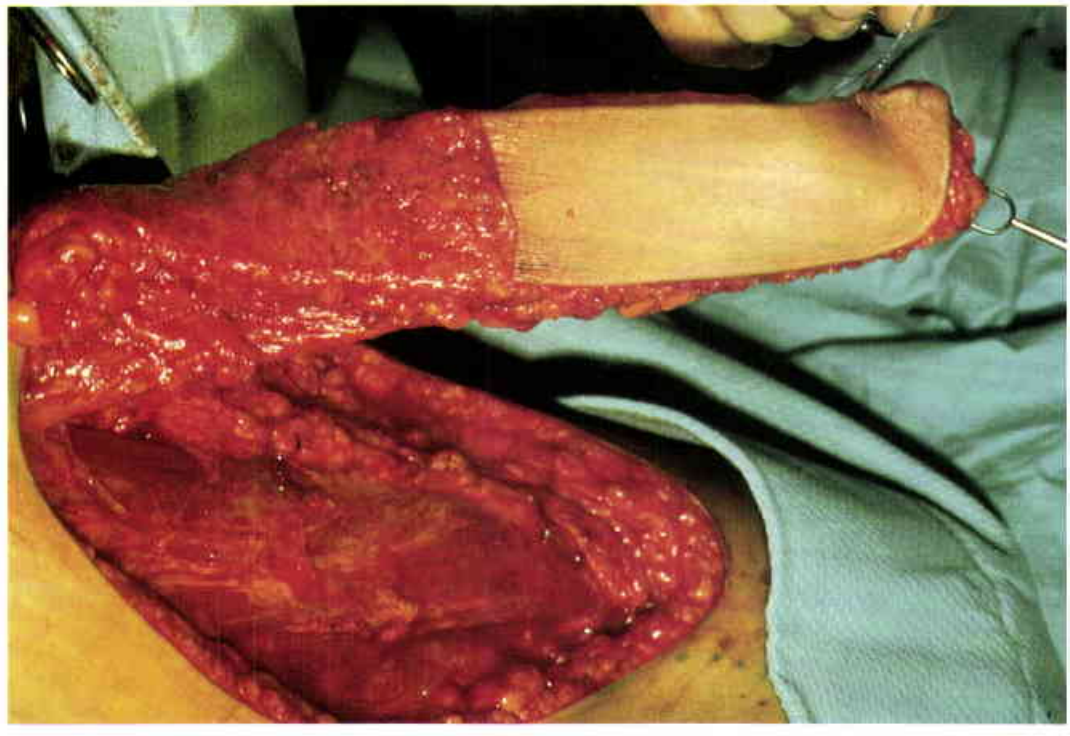
9

Upward rotation of the flap is ultimately limited by the dominant vascular pedicle, which should lie approximately nine to ten centimeters below the inguinal ligament. The flap will reliably cover the medial two-thirds of the groin.



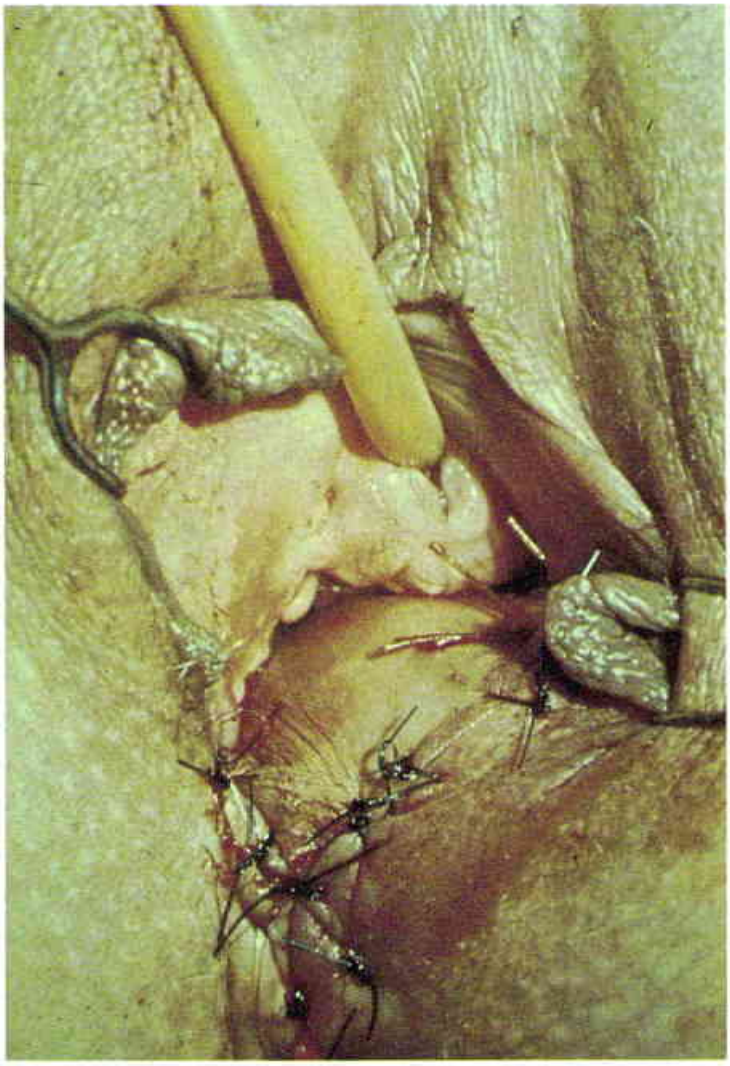
10

Forty-eight-year-old patient five years following an abdominoperineal resection for carcinoma of the rectum. The posterior two-thirds of the vagina was removed. Only the vaginal mucosa overlying the bladder remained. Closure was affected by approximating this mucosa to the adjacent skin. Separation of the vaginal mucosa and the perineal skin demonstrates the magnitude of the soft tissue loss. This case is of historical interest because it was the first vaginal reconstruction performed using a gracilis myocutaneous flap. (Case of J.B. McCraw)

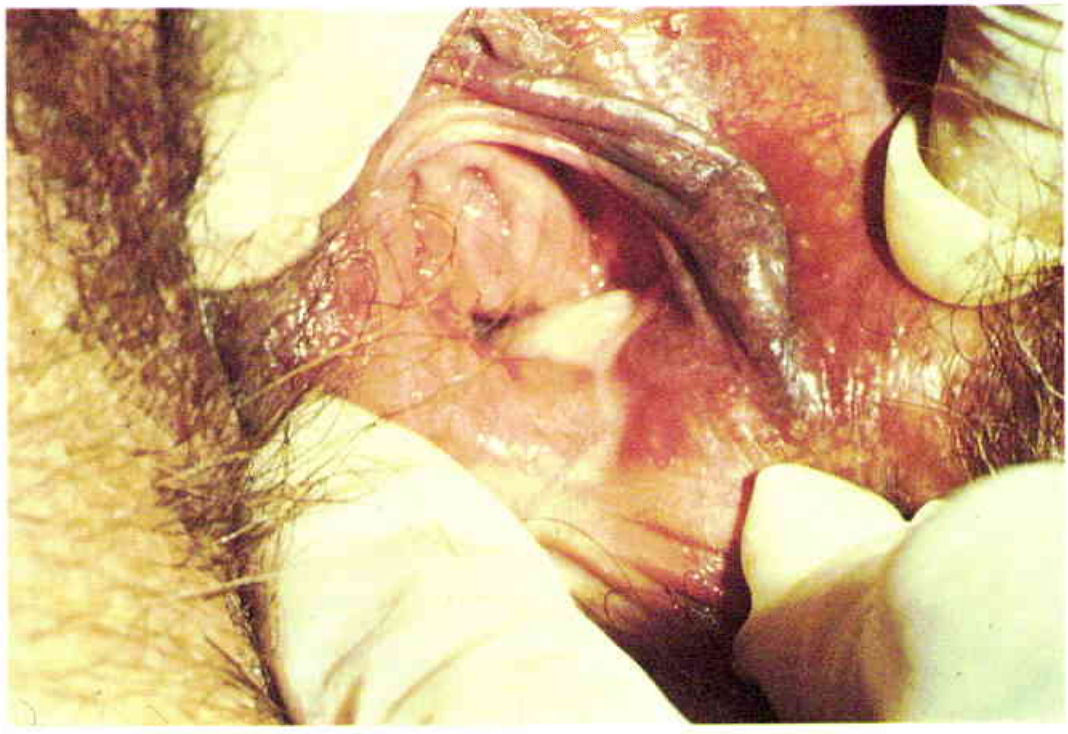


11

The proximal half of the cutaneous segment was deepithelialized. At the time it was not known whether this proximal skin contributed to the blood supply of the distal skin of the myocutaneous flap.

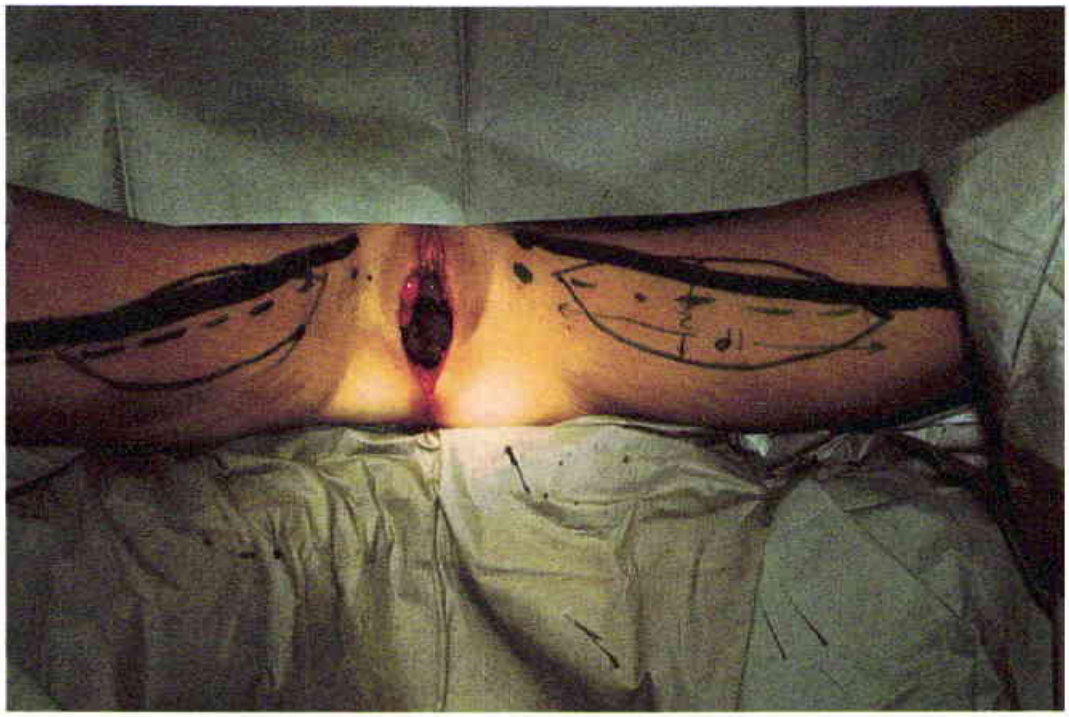


12
Inset of the gracilis flap to replace the posterior two-thirds of the vagina. It was possible to bury the flap and to close the perineal skin primarily.



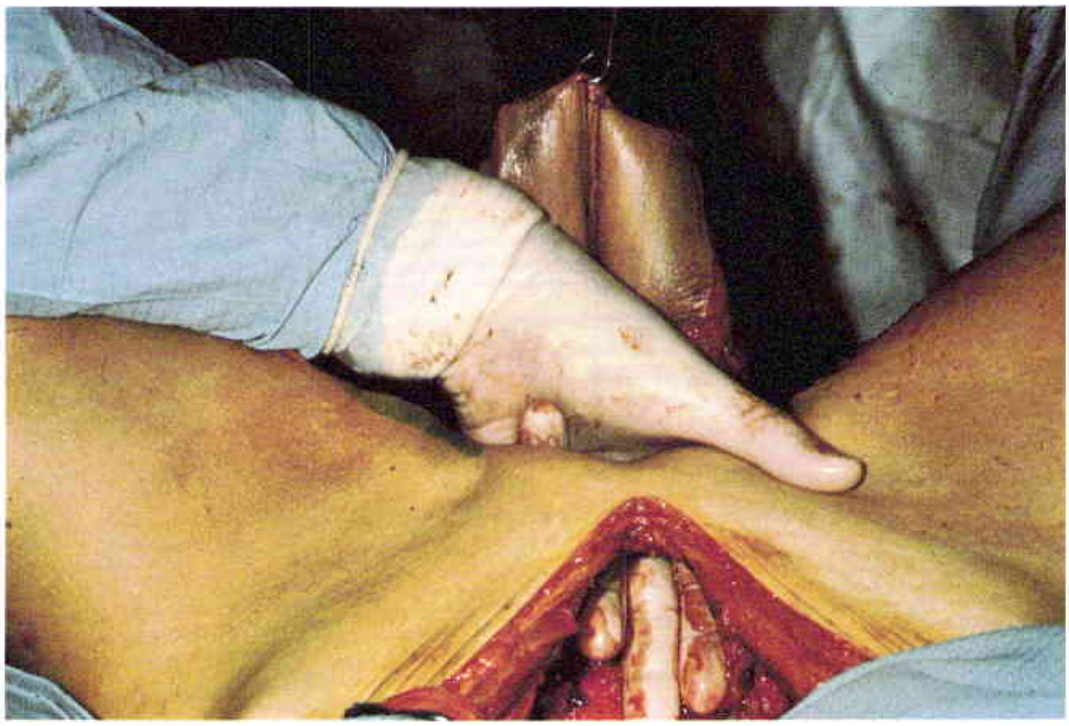
13
Close-up view of the healed gracilis myocutaneous flap (white) replacing the posterior wall of the vagina. Although the flap was in contact with secreting vaginal mucosa, it did not become macerated.

14
The size of the introitus was acceptable, and the patient returned to normal intercourse.



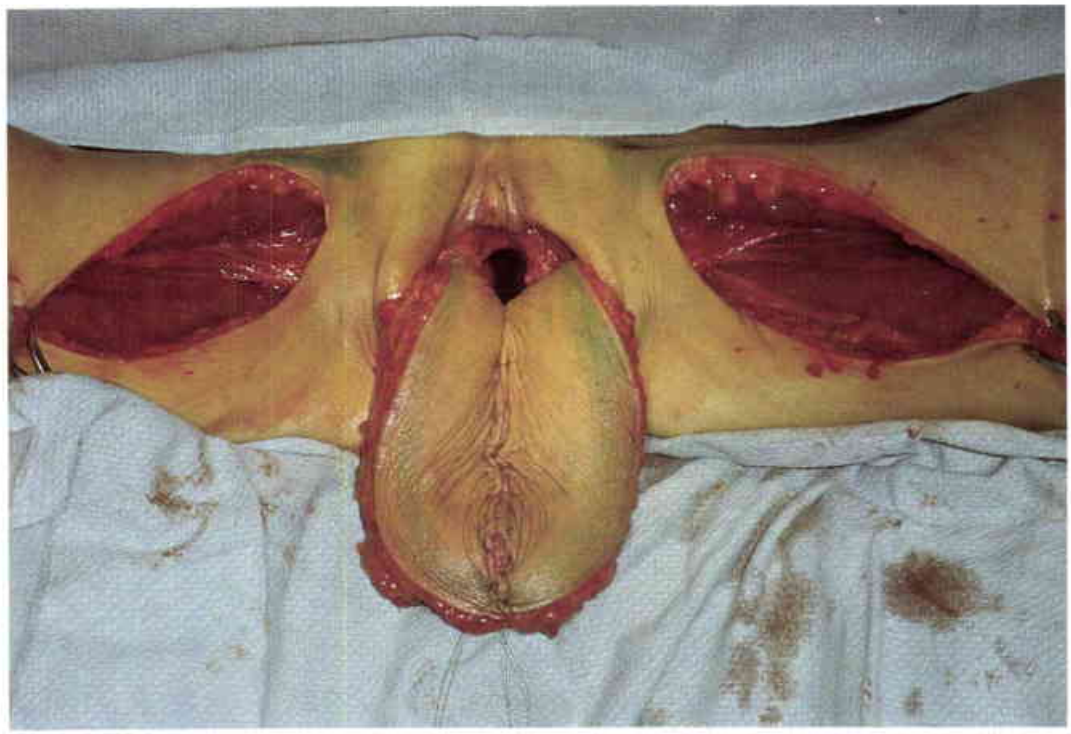
15

Thirty-nine-year-old patient with a recurrent carcinoma of the cervix following irradiation therapy which required a Wertheim hysterectomy. The reconstructive team was able to perform the vaginal reconstruction while the ileal loop was being constructed. This prevented any prolongation of the operative time, and it did not interfere with the completion of the abdominal closure. This case is of historical interest because it was the first immediate vaginal reconstruction performed at the Wilford Hall USAF Hospital in 1974. (Case of J.B. McCraw and F. Massey)

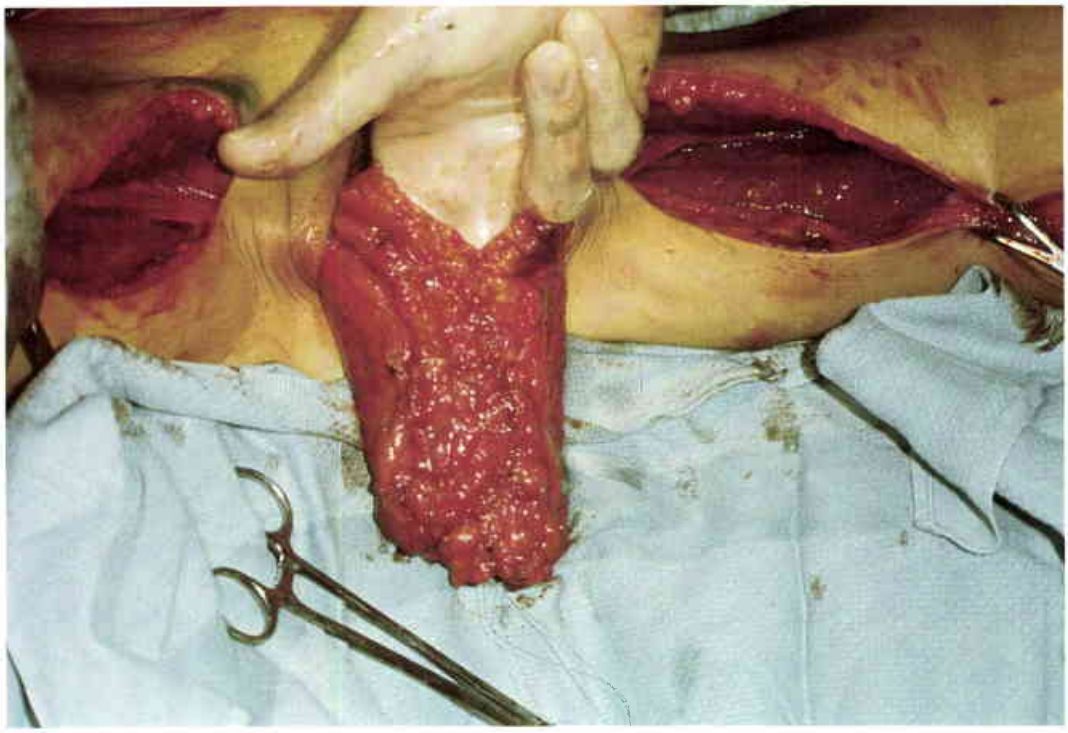


16

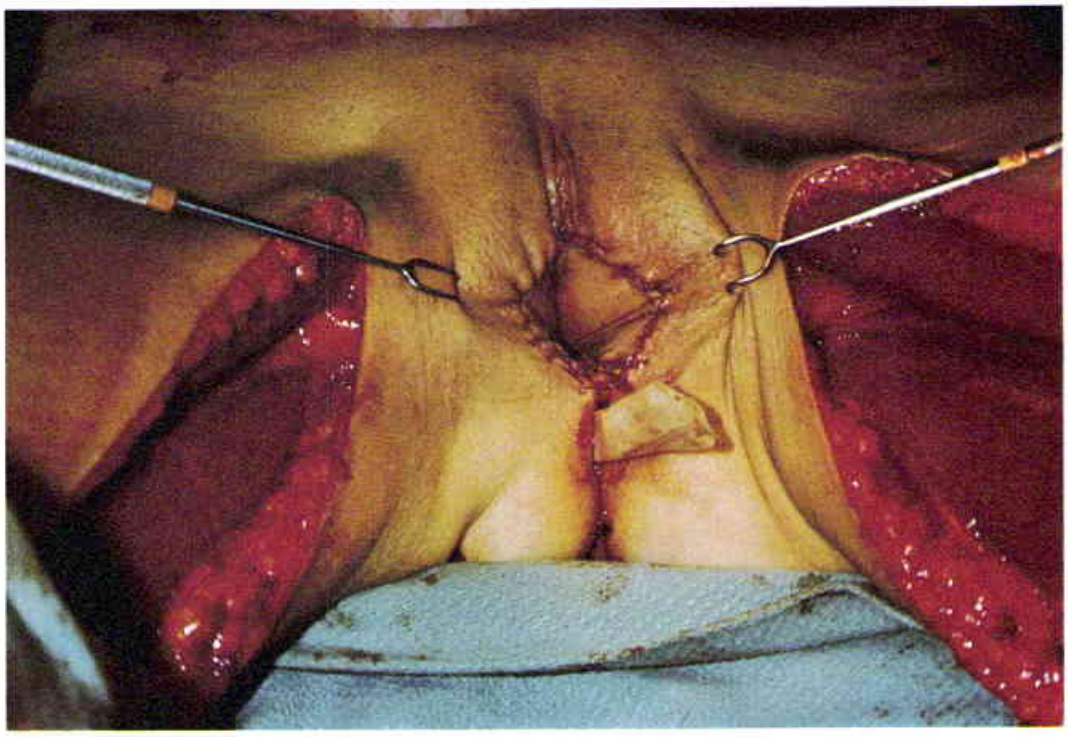
The extent of the pelvic defect is demonstrated at the time of the radical exenteration. The bilateral gracilis myocutaneous flaps effectively obliterate the massive pelvic dead space and prevent herniation of the small bowel.



17
The bilateral gracilis myocutaneous flaps are approximated in the midline. Once the flaps are introduced into the pelvis, this suture line will become the anterior vaginal wall.

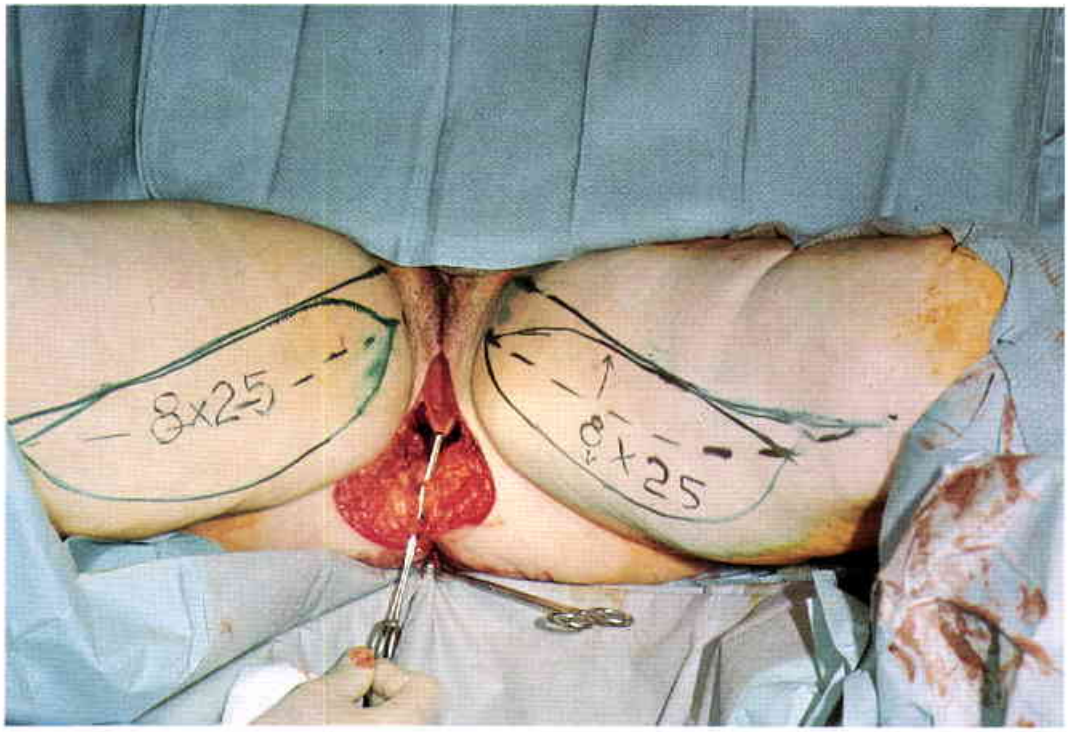


18
Completion of the posterior suture line closure recreates the neovaginal pouch. The gracilis muscles are seen on either side of the cutaneous closure.

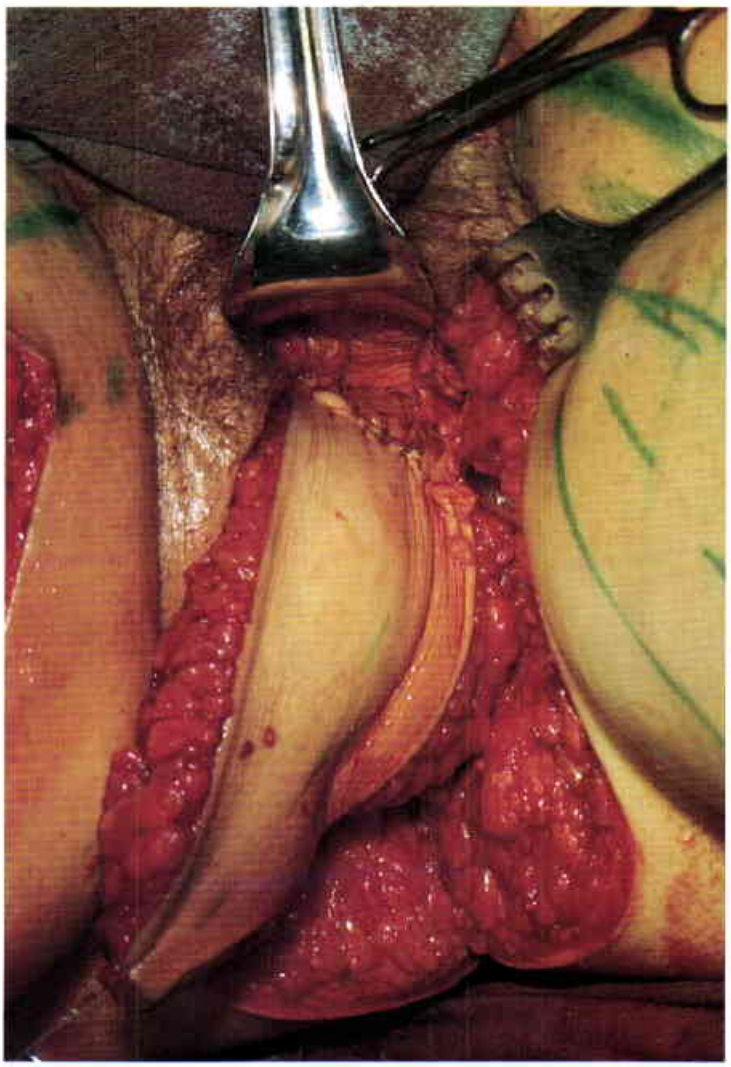


19
Immediate inset of the flaps into the pelvis. Internal suture fixation of the flaps is not necessary to prevent prolapse.

20
Late postoperative view of the introitus and the donor site. It is preferable to introduce some triangulation into the surface closure to prevent a circular scar contracture.



21
Forty-six-year-old patient with an extensive carcinoma of the anus. The resection included the rectum and anus as well as the posterior two-thirds of the vagina and the surrounding skin. The remaining cuff of anterior vagina is retracted with a clamp. Large gracilis flaps are outlined to provide adequate soft tissue for both vaginal reconstruction and perineal coverage. In the obese patient one must be careful to place the skin segment accurately on the muscle surface because the skin falls posteriorly in the supine position. (Case of J.B. McCraw and P.K. Carlton)



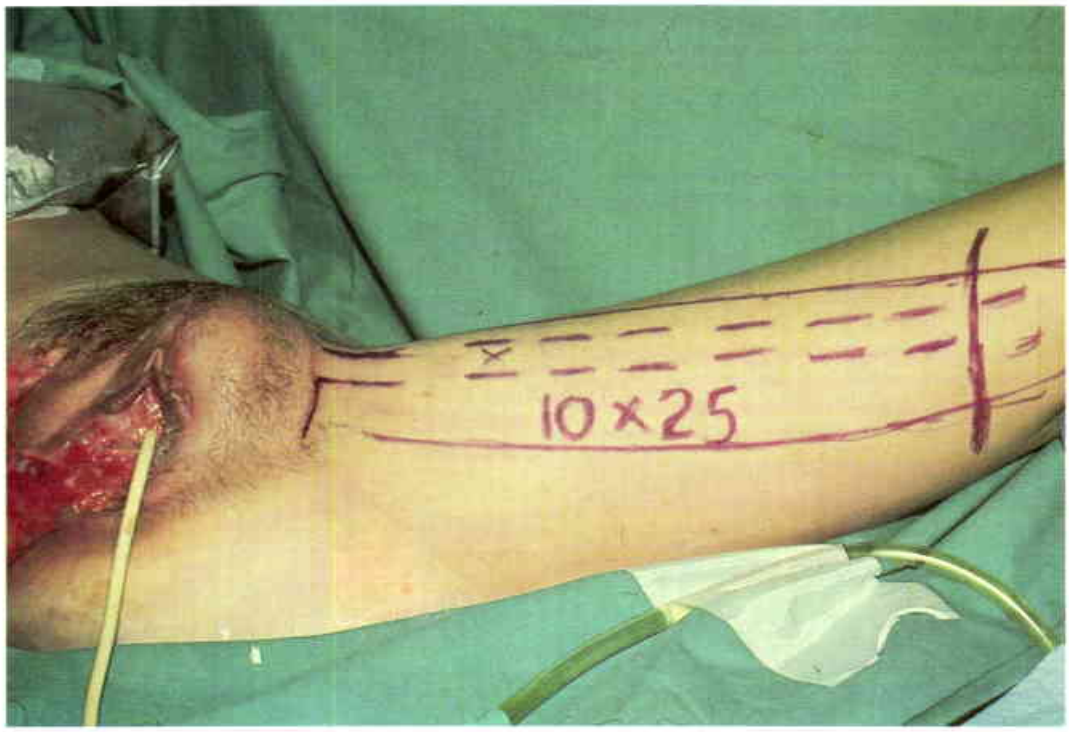
22
The right gracilis flap was used for the hemivaginal reconstruction. The left gracilis flap will be used to correct the remaining surface defect.

23
The majority of the perineal surface was replaced by the left gracilis myocutaneous flap. Only a small portion of the right gracilis myocutaneous flap is visible at the introitus. The donor sites were primarily closed with #2 nylon sutures with bolsters.

24
At six months the flaps were still bulky. They did provide a primarily healed wound and an adequate introitus.

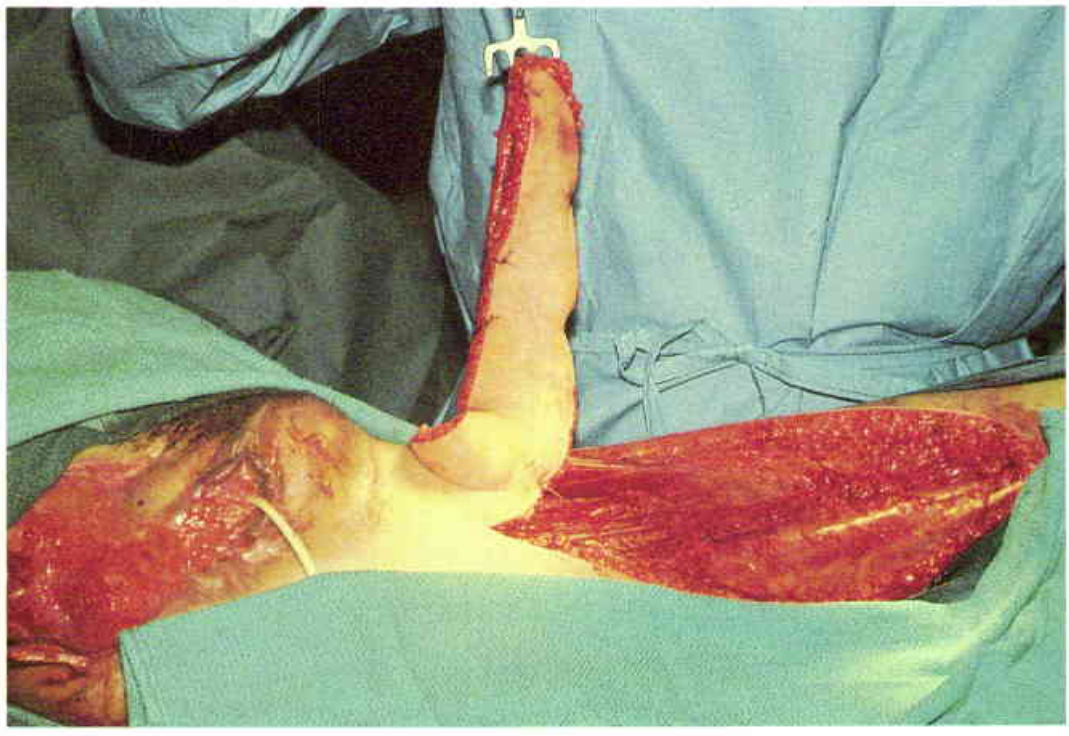
25

Nineteen-year-old patient who sustained a traumatic hemipelvectomy in a motorcycle accident. The ileum was totally avulsed from the sacrum and carried the iliac artery with the leg. In the process of secondary healing, the vagina and anus were lateralized and fused. The majority of the posterior vagina was also lost. This patient was extremely lucky to have survived the injury since only thirteen survivors have previously been reported in the world literature. (Case of J.B. McCraw and S. Philippakis)



26

A very wide gracilis myocutaneous flap was outlined on the remaining leg to give an adequate amount of soft tissue to correct the perineal defect.

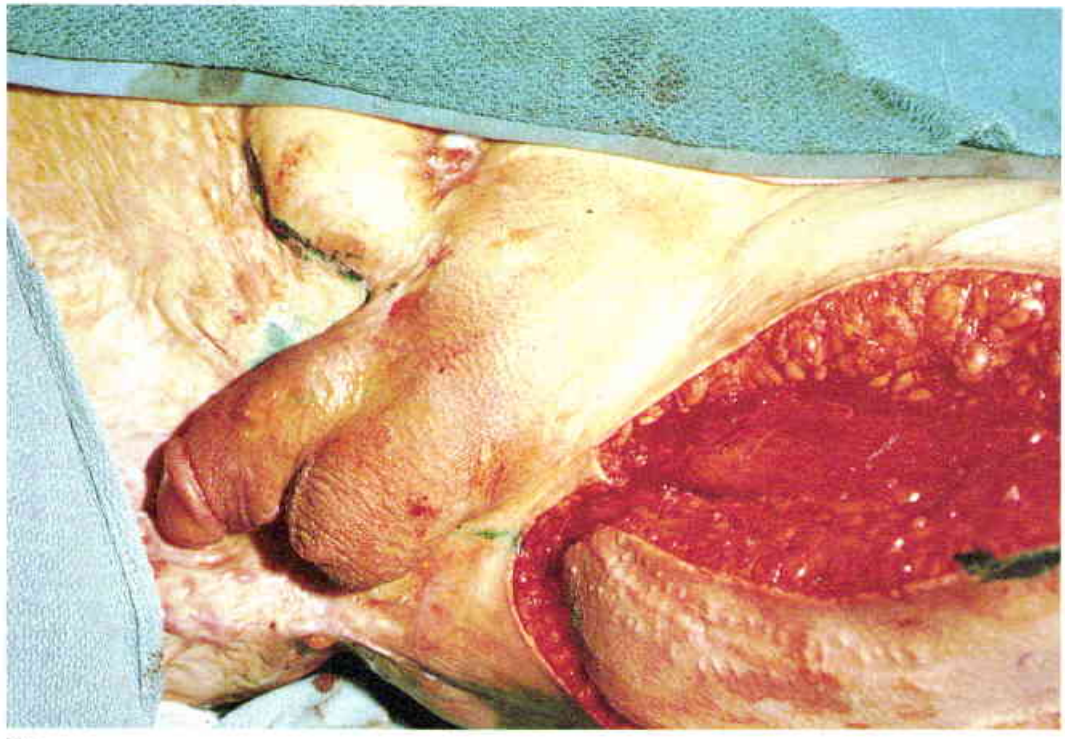


27
An "island" flap was not created in an effort to enhance the viability of the cutaneous segment. Every precaution was taken with this flap since it was thought to be the only flap available in the absence of the opposite inferior rectus abdominis flap.

28
Close-up view of the introitus of the centrally relocated vagina. It was not necessary to replace the lost posterior vaginal wall after repositioning the vagina.

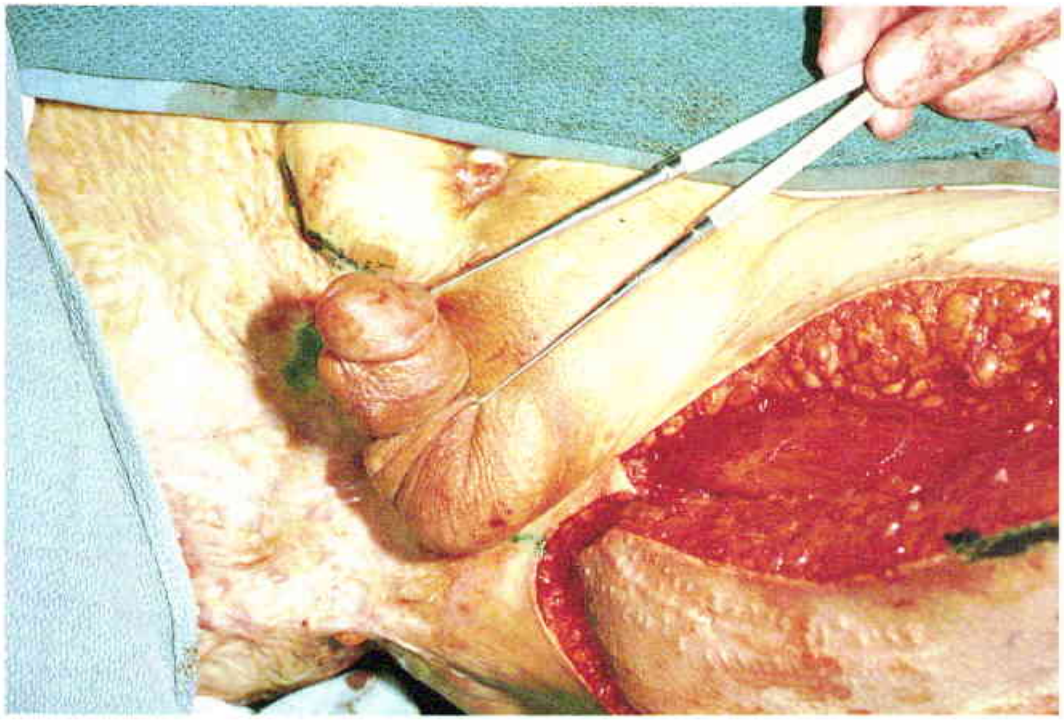
29

Lateral view of the healed gracilis flap which separates the vagina and anus. The adjacent pelvic wall defect was skin grafted.



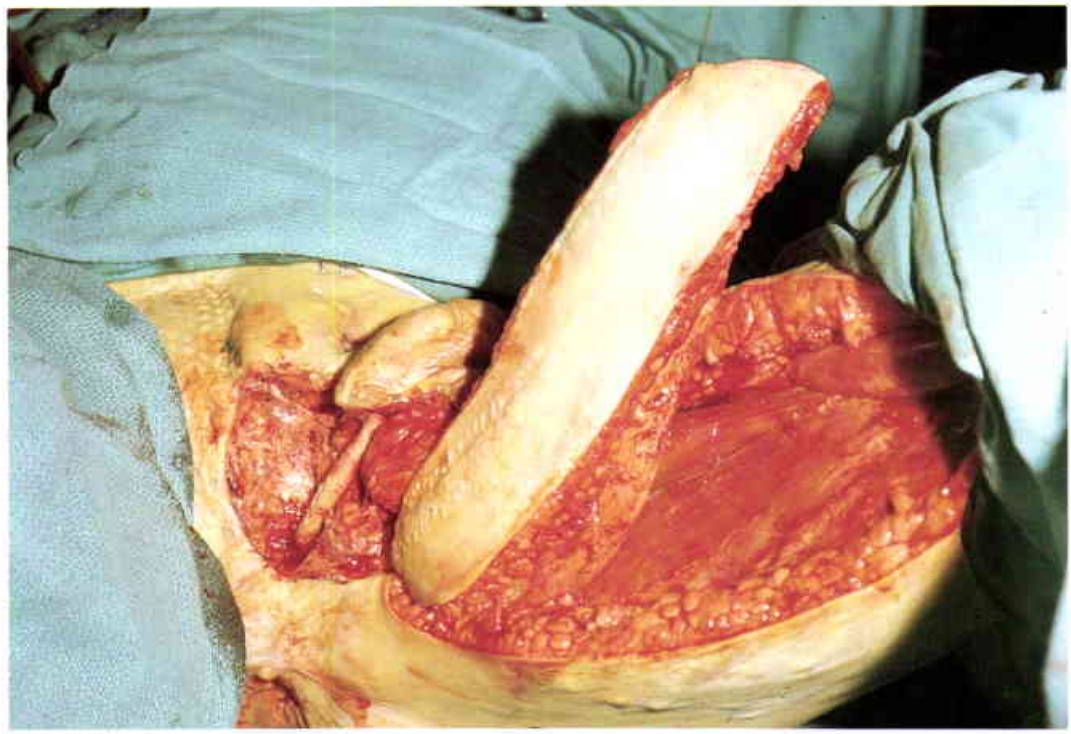
30

Nineteen-year-old male who sustained a high voltage electrical injury when he parachuted onto a high tension wire. This resulted in the loss of the medial right thigh musculature, the adjacent perineum, half of the scrotum, and the proximal urethra. A gracilis myocutaneous flap was elevated in the left thigh and examined with fluorescein prior to the recreation of the deformity. The scar in the left gracilis cutaneous segment is from the removal of the saphenous vein, which was used to repair the right femoral artery. It was not then known if this scar would harm the vascular connections between the muscle and the skin. (Case of J.B. McCraw, C.E. Horton, P.C. Devine and C.J. Devine, Jr.)



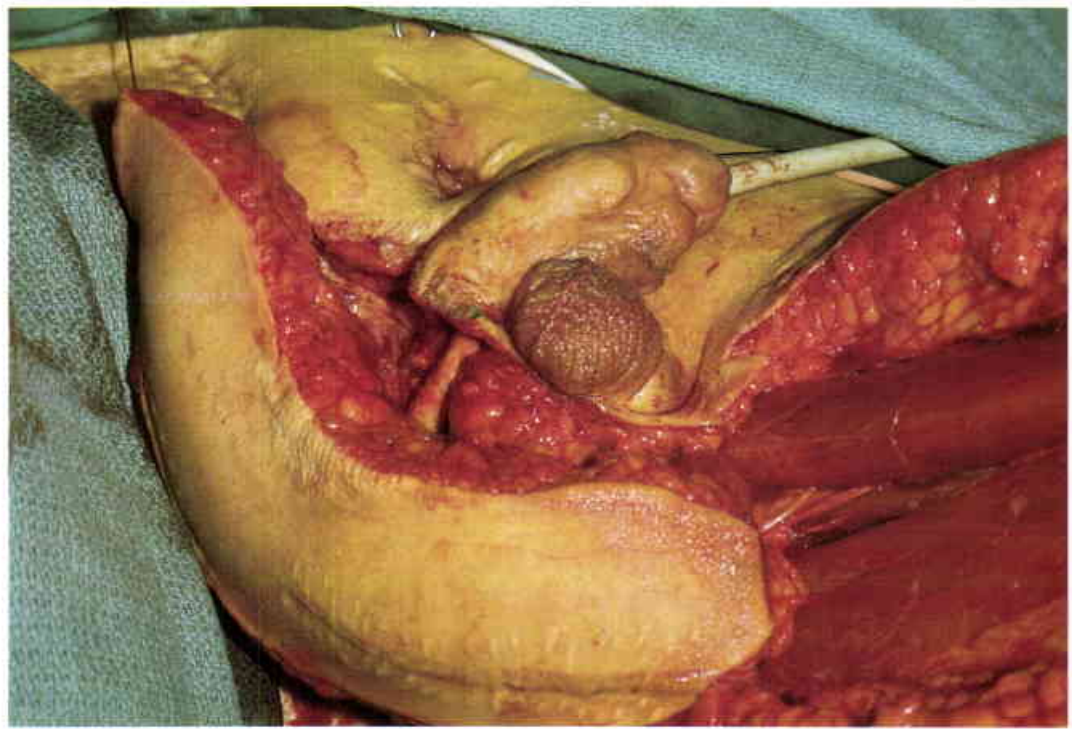
31

The penis and remaining scrotum are retracted to demonstrate the perineal contracture.



32

Elevated gracilis myocutaneous flap and the perineal deformity. The ten centimeter gap of urethra between the bladder neck and the penile urethra was replaced with a full-thickness tube graft. This case is memorable to the author because it was the first myocutaneous flap done in Norfolk in 1975.



33

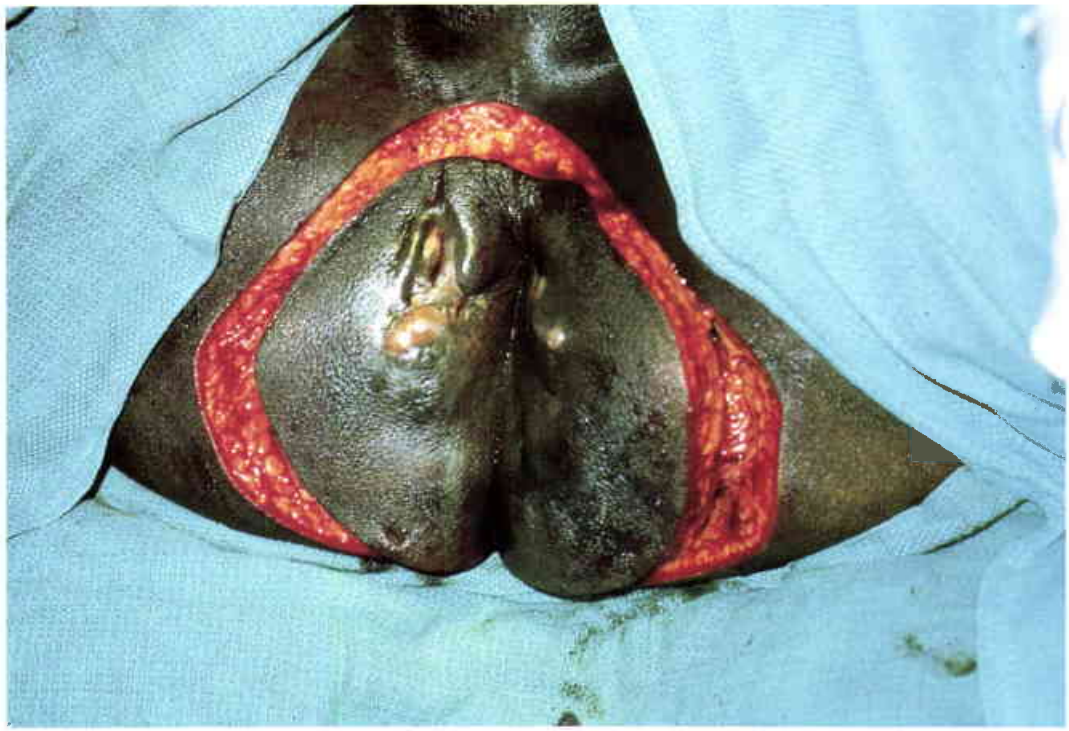
Rotation of the gracilis flap into the perineum. The distal one-third of the gracilis muscle was wrapped around the neourethral graft to facilitate its revascularization. The adductor longus, brevis, and magnus muscles are outlined in the donor thigh. The sartorius muscle crosses the distal wound.

34

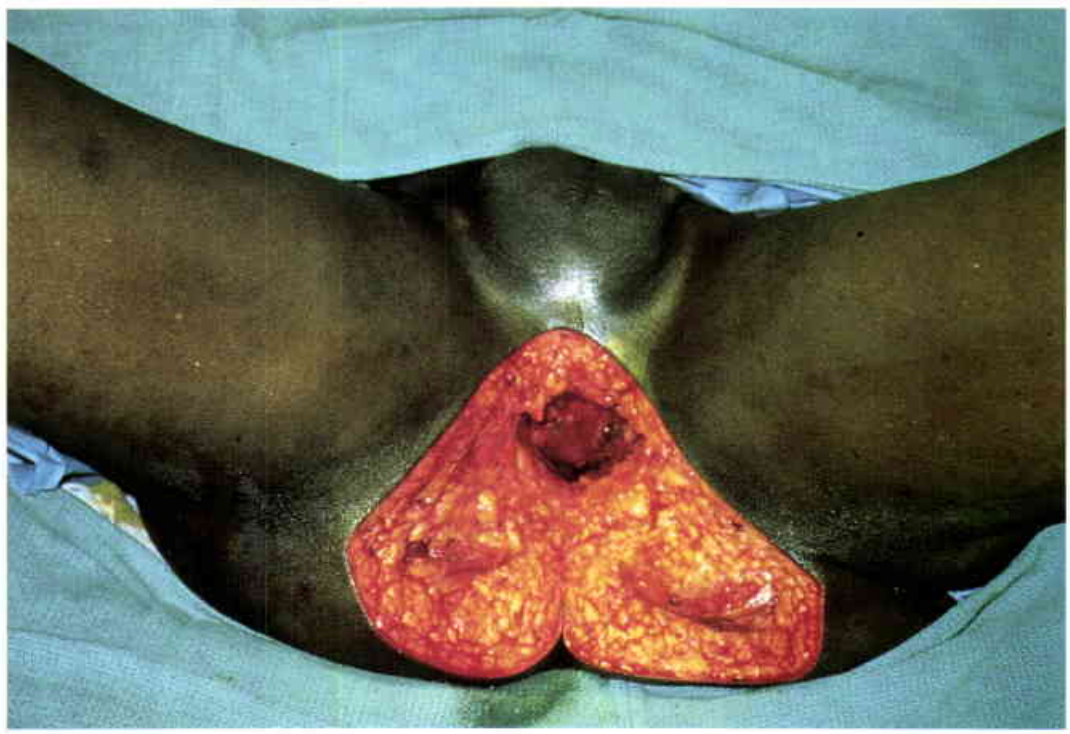
Healed gracilis myocutaneous flap which resurfaces the perineum and a portion of the suprapubic area. The patient developed urinary continence and a normal stream. A penile stiffener allowed the patient to have intercourse.

35

In a later stage the flap was turned into the perineum to release the anal contracture. The proximal muscle and the dominant blood supply of the flap were divided at this stage without harm to the flap.



36
Fifty-eight-year-old man with Crohn's disease of the perineum. This was complicated by an anal carcinoma which invaded numerous sinus tracts. The carcinoma appeared to be unresectable. (Case of J.B. McCraw and G. Hoffman)



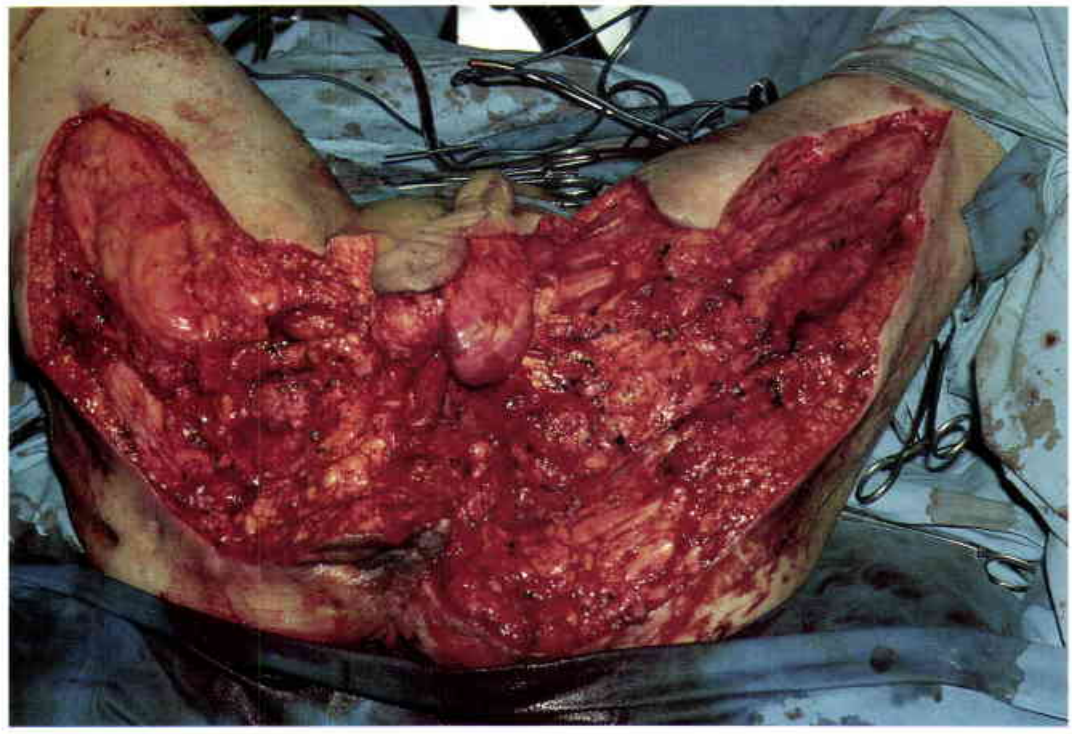
37
Perineal defect following resection. It was necessary to remove a large amount of buttock skin in order to excise the tumor infiltrated sinus tracts.

38
The right gracilis myocutaneous flap was used for perineal and posterior buttock coverage. The left gracilis myocutaneous flap was deepthelialized in its distal half to obliterate the pelvic dead space. The proximal portion of the left gracilis flap was used for perineal coverage.

39
Healed gracilis flaps two years following resection of the anal carcinoma. The patient is alive and well six years following surgery.

40

Fifty-five-year-old paraplegic male with a thirty-five-year history of bilateral ischial ulcers. Unfortunately all of the biopsies proved to be low-grade squamous cell carcinoma. A diverting colostomy was performed prior to the resection. (Case of P.G. Arnold)



41

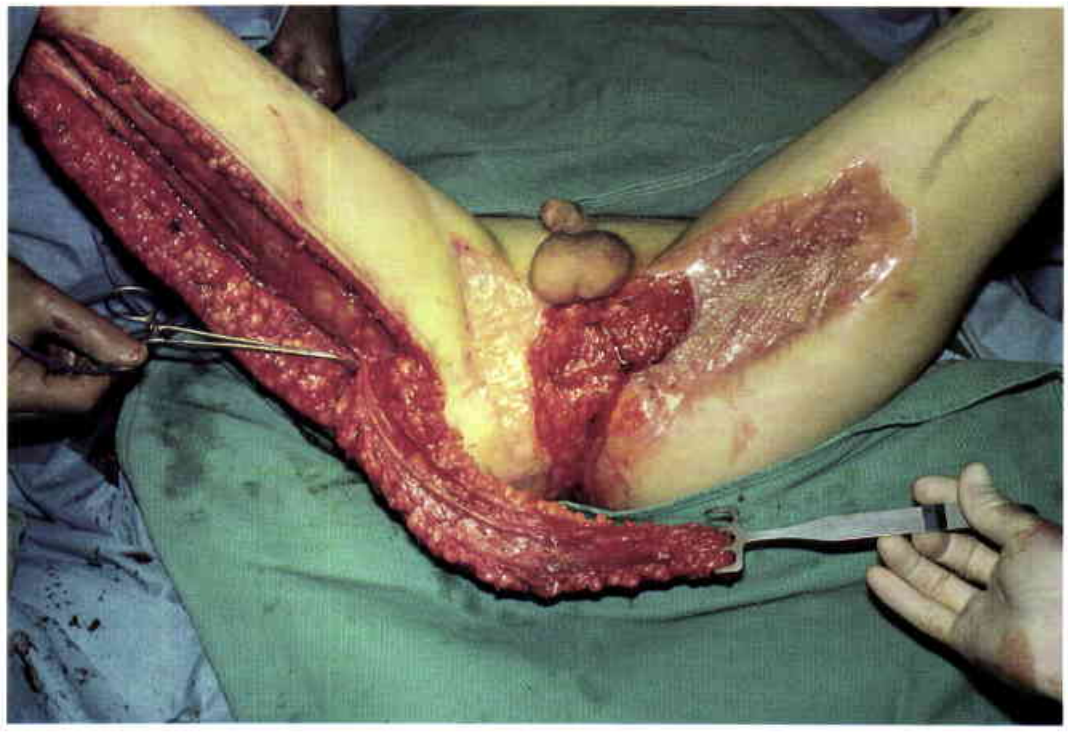
A wide excision of all of the tumor was carried out with histologic control of the margins. Because of the dimensions of the operative defect a total thigh flap was necessary to correct the massive deformity.

42
The anus was brought through the flap at the level of the patella. The defect on the right posterior thigh was closed directly.

43
The wound healed primarily. The patient has survived for nine years.

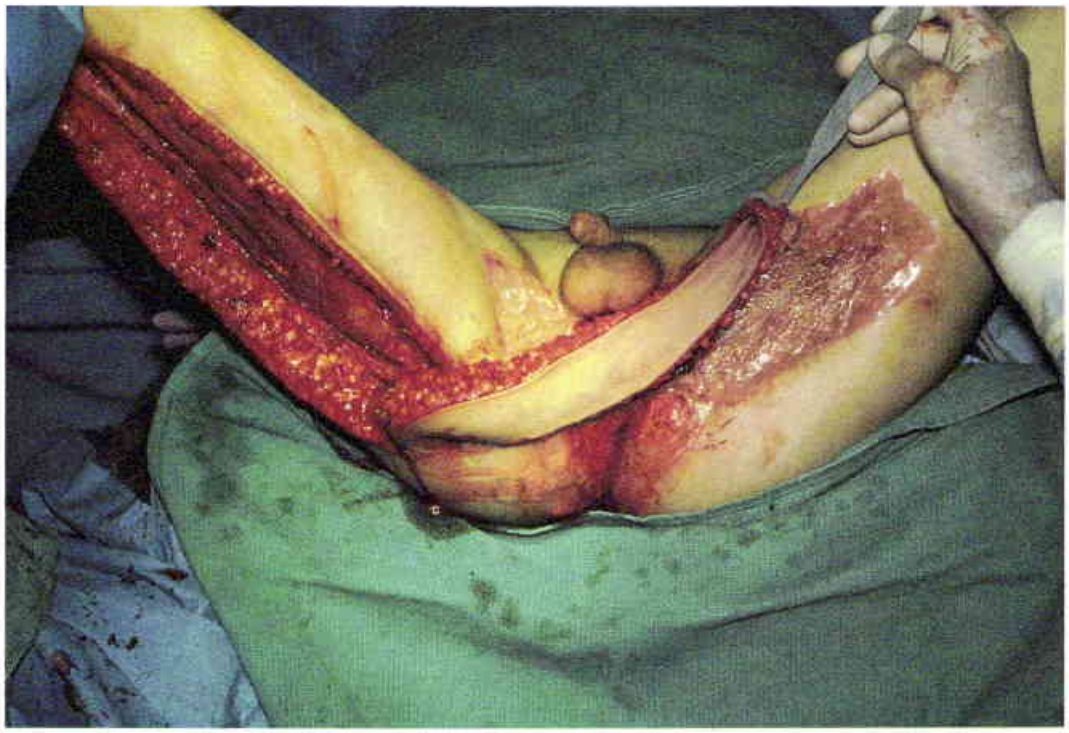
44

Eleven-year-old boy who sustained a fourth degree burn of the perineum while pinned beneath a hot muffler. The urethra between the bladder neck and the penis was totally lost. The anus was also destroyed. A colostomy had been done previously to protect the perineal burn and later skin grafts. (Case of J.B. McCraw, C.J. Devine, Jr., and G. Harkins)

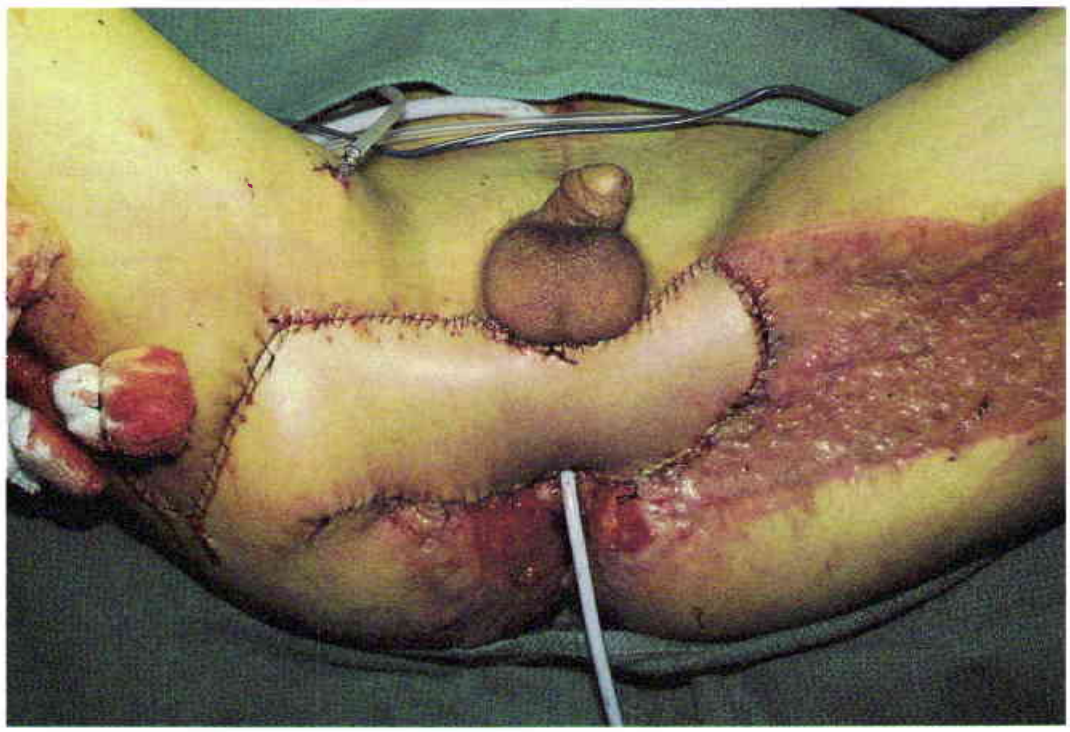


45

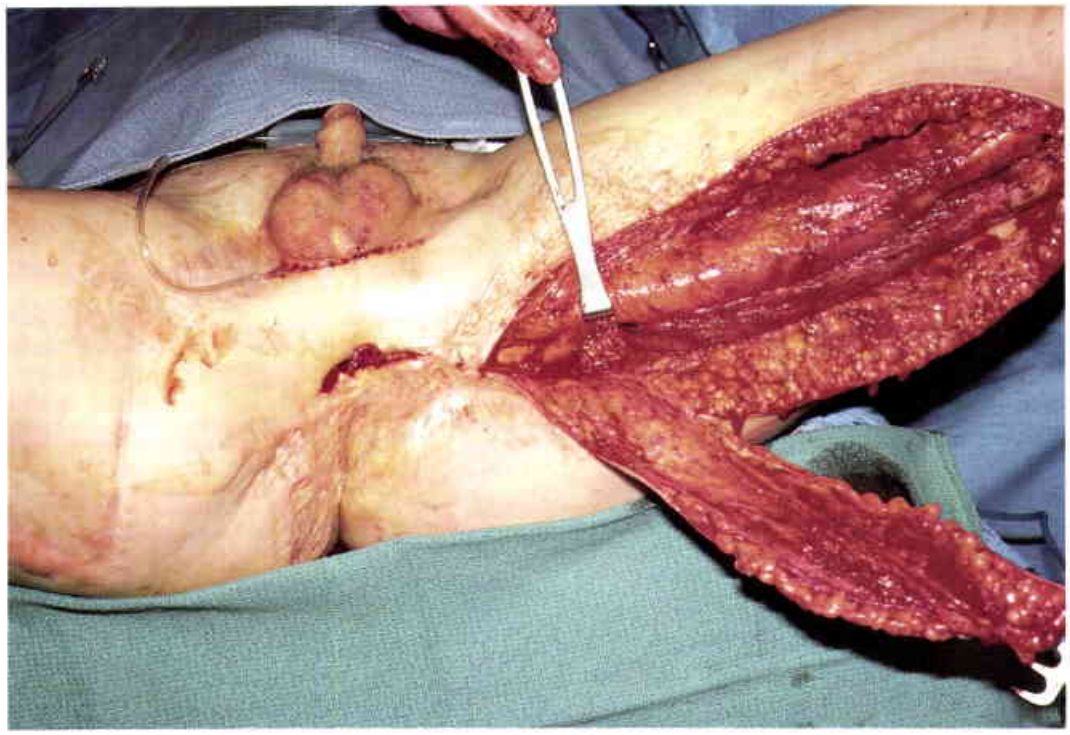
Elevated gluteal fasciocutaneous flap with the posterior cutaneous nerve of the thigh visible on the deep fascial surface. The neurovascular bundle is pointed out.



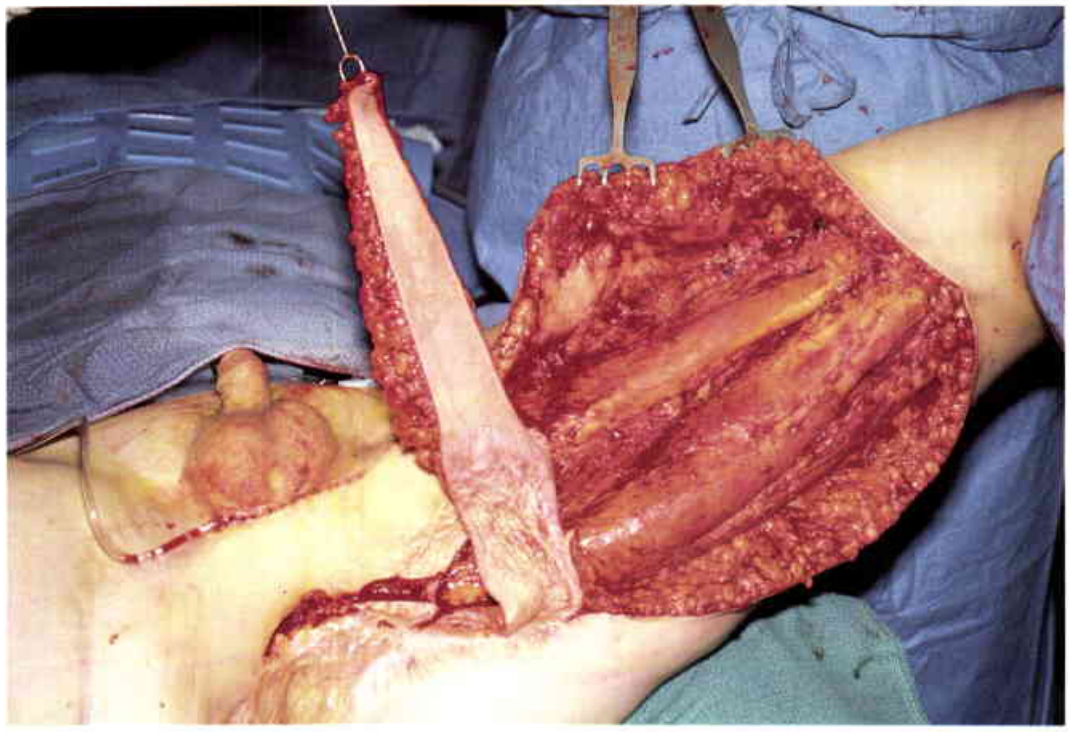
46
The posterior thigh flap was chosen for perineal coverage so the gracilis muscles could be preserved for a later reconstruction of the anal sphincter.



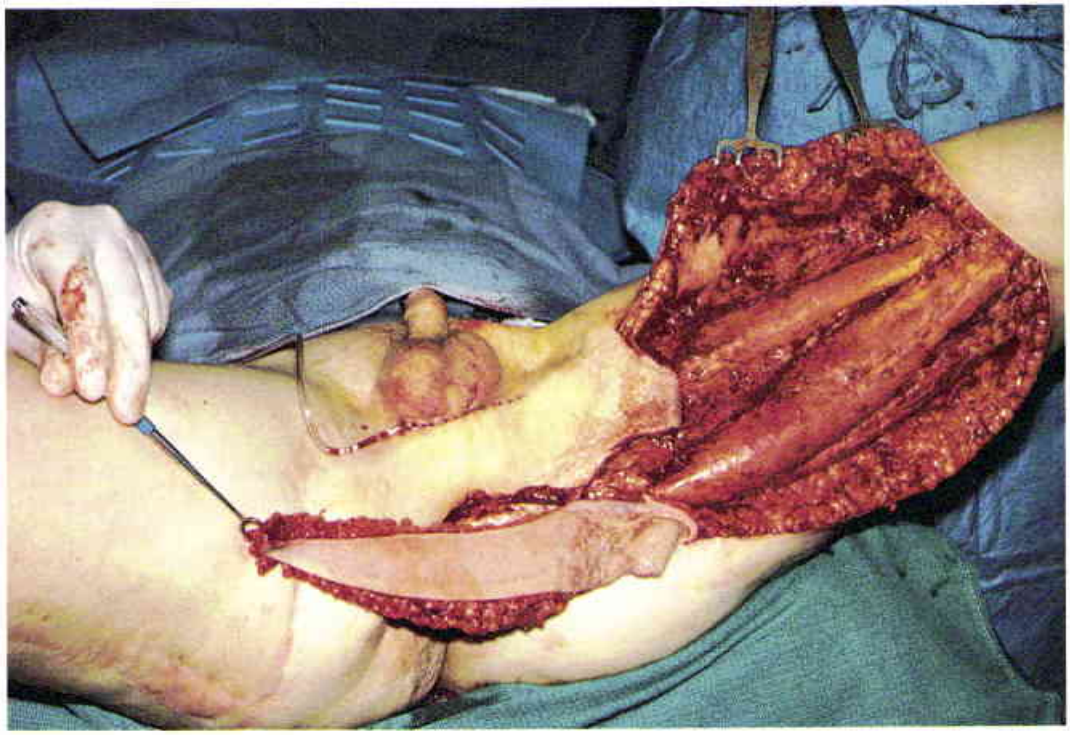
47
Transposed flap with the perineal urethrostomy in place. At the second stage, a ten centimeter tube graft urethroplasty was performed beneath the flap.



48
Identification of the inferior gluteal vessels at the "base" of the opposite posterior thigh flap which was covered with a skin graft. Since the posterior cutaneous nerve of the thigh was intact it was presumed that the deeply placed inferior gluteal vessels had survived the burn injury.



49
Elevated flap. Note the skin graft in the "base" of the fasciocutaneous flap. The skin graft had created a defacto "island" neurovascular flap.



50
Flap transposed to the posterior perineum. The perineal urethrostomy was closed at this stage and urinary continence was reestablished.

51
Healed flaps which resurfaced the entire perineum. The anal incontinence was corrected by a local plastic procedure, and the colostomy was removed. Bowel and bladder function was returned to normal.

TENSOR FASCIA LATA

ANATOMICAL CONSIDERATIONS

Surface Markings

If one draws a line passing from the greater trochanter to the midlateral aspect of the knee, this line should bisect the center of the tensor fascia lata (TFL) flap. The anterior border of the TFL flap extends to the margin of the rectus femoris muscle, and the posterior border extends to the margin of the biceps femoris muscle. The tensor muscle, itself, is usually palpable just distal to the greater trochanter.

Origin and Insertion

The tensor muscle originates partially from the anterior superior iliac spine but more extensively from the greater trochanter of the femur. The fascia lata extension of the small tensor muscle inserts into the lateral aspect of the knee and acts as a lateral knee stabilizer. This limits the usefulness of the TFL flap in an athletic individual because its sacrifice can contribute to lateral knee instability.

Adjacent Muscle

The tensor muscle lies between the biceps femoris and rectus femoris muscles. The vastus lateralis muscle is attached to the deep surface of the tensor fascia lata flap throughout its course.

Vascular Pattern

The tensor muscle is supplied by the lateral circumflex femoral vessels which also supply the rectus femoris and vastus lateralis muscles. All of these terminal vessels are end-arteries of the profunda femoris vessels and enter the three muscles approximately eight to ten centimeters below the inguinal ligament. There is a significant cutaneous vessel in the proximal skin of the flap, but the dominant blood supply to the TFL cutaneous segment is contributed by the extensive vascular network on both sides of the fascia lata. The skin in the distal and lateral one-third of the thigh is predominatly supplied by direct cutaneous perforators from the vastus lateralis muscle. The relative dominance of these distal perforators limits the effective dimensions of the TFL flap, unless it is "delayed."

Motor Nerve

Inferior branch of the gluteal nerve L4-5.

Sensory Nerve

Lateral femoral cutaneous nerve, L1-3.

USES

Although the arc of rotation of the TFL flap extends from the ischium to the groin and, finally, to the abdomen, its applications are generally limited to the structural reconstruction of the abdominal wall and the replacement of groin skin. The tensor fascia will reach the chest wall margin if the tensor muscle is completely detached from its origin and raised as a pure "island" myofascial flap, as was first done by Waagensteen in 1933. Lower abdominal defects are more easily closed with the adjacent rectus femoris muscle flap which carries an even tougher fascial layer. A simple TFL rotation flap offers the most expeditious method to resurface major groin skin defects. Both the vastus lateralis muscle flap and the inferiorly based rectus abdominis muscle flap can be used for similar groin defects, but their dissection is more complex and their donor sites are even less desirable than that of the TFL flap. The TFL flap is exceedingly useful in spina bifida patients because of its ability to introduce cutaneous sensibility into the sitting area. It is seldom considered for a deep ischial ulcer because of its inability to obliterate the resulting excisional cavity.

REGIONAL FLAP COMPARISONS

The TFL flap is usually compared to the vastus lateralis muscle flap and the rectus femoris muscle or musculocutaneous flaps. The vastus lateralis muscle flap can be used to resurface exactly the same areas as the TFL flap, and it also has the advantage of adding muscular capabilities. The fascia of the vastus lateralis muscle is not as strong as the tensor fascia, but it is still adequate for a full-thickness abdominal defect. Unfortunately, the dissection of the vastus lateralis muscle flap is tedious and bloody. This limits its usefulness for abdominal wall and groin defects. The rectus femoris flap can also carry a similar amount of skin as the TFL flap if the anterior fascia lata is left attached to the rectus femoris muscle. It can be more useful for lower abdominal wall reconstructions because the fascia incorporated on the undersurface of the rectus femoris muscle is even stronger than the fascia lata of the TFL flap. For this reason the rectus femoris muscle alone is usually preferred over the TFL flap for lower abdominal defects or in situations where muscle is needed to obliterate a deep cavity. Even when the transposed rectus femoris muscle flap must be skin grafted, it is the simplest flap to use for osteo-

myelitis of the iliac crest and the hip joint. The V-Y biceps femoris myocutaneous flap is the traditional choice for standard ischial ulcers, unless one is attempting to introduce sensation into the sitting area with the TFL flap. The standard TFL flap will barely cover the ischial tuberosity, and it will not obliterate the usual ten by ten centimeter cavity which results from an ischiectomy.

DISADVANTAGES

The distal one-third of the lateral thigh skin receives its blood supply from the underlying vastus lateralis muscle perforators. This effectively limits the distal extent of the TFL flap unless it is "delayed." The TFL donor site usually can be primarily closed if the flap is no more than ten centimeters in width. When a skin graft is necessary, the "take" of the skin graft on the donor site (vastus lateralis muscle) is quite acceptable, but the esthetic deformity can be significant. Prolonged drainage from the donor site is a common problem; it can easily persist for several weeks when it occurs. A more significant disadvantage is the occasional knee instability which results from the loss of the lateral tensor band. In one case it was necessary to transfer the rectus femoris tendon into the distal tensor band to correct the lateral knee instability which resulted from the use of the TFL flap. It may be possible to circumvent knee instability by attaching the distal cut margin of the tensor band into the proximal fascia of the vastus lateralis muscle. It was initially thought that the use of rectus femoris flap would cause a greater functional loss than the TFL flap, but this has not been the case. Because it is primarily a fasciocutaneous flap, the TFL flap is not effective in correcting contaminated wounds or in obliterating cavities.

ADVANTAGES

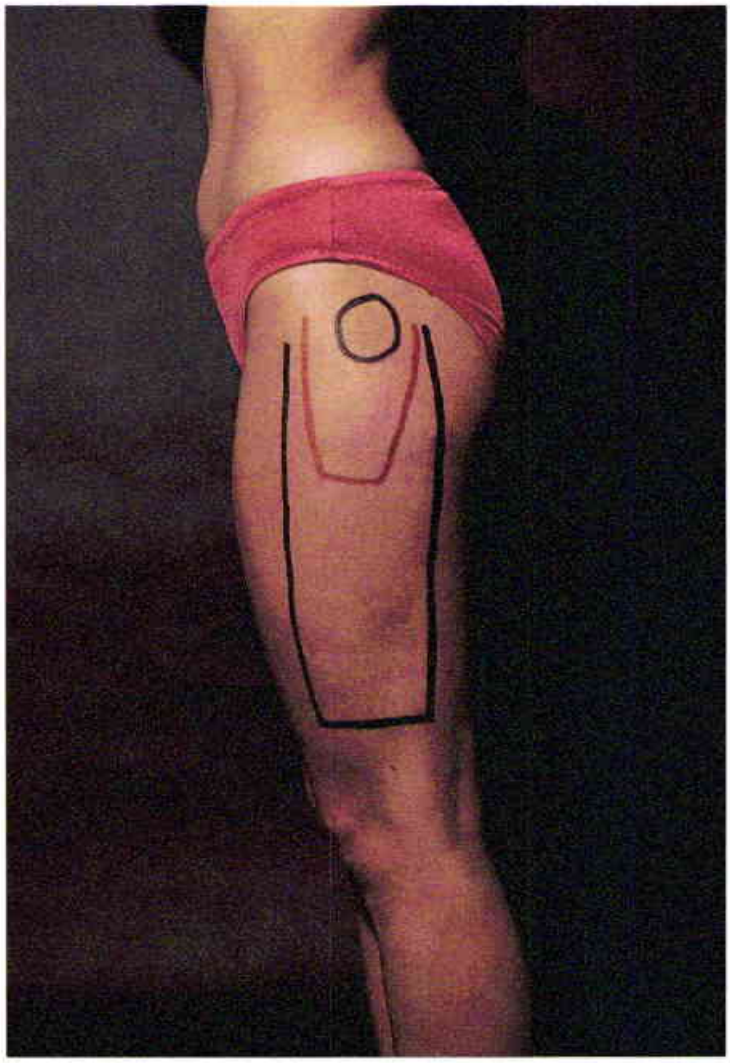
The TFL unit is versatile because it can be used either as a fasciocutaneous or myofascial flap. It is innervated by a predictable sensory branch (lateral femoral cutaneous nerve), which is easily visualized between the iliac crest and the lateral border of the rectus femoris muscle. The lateral femoral cutaneous nerve has made the flap particularly useful for ischial coverage in meningomyelocele patients, since this L1-3 sensory area is spared in the majority of these patients and can be used to transfer sensate skin to the ischium. As a myofascial flap it is certainly the most useful tissue for middle and upper abdominal wall reconstructions, as well as for the difficult problem of the recurrent inguinal hernia.

COMPLICATIONS, PITFALLS, AND DONOR SITE

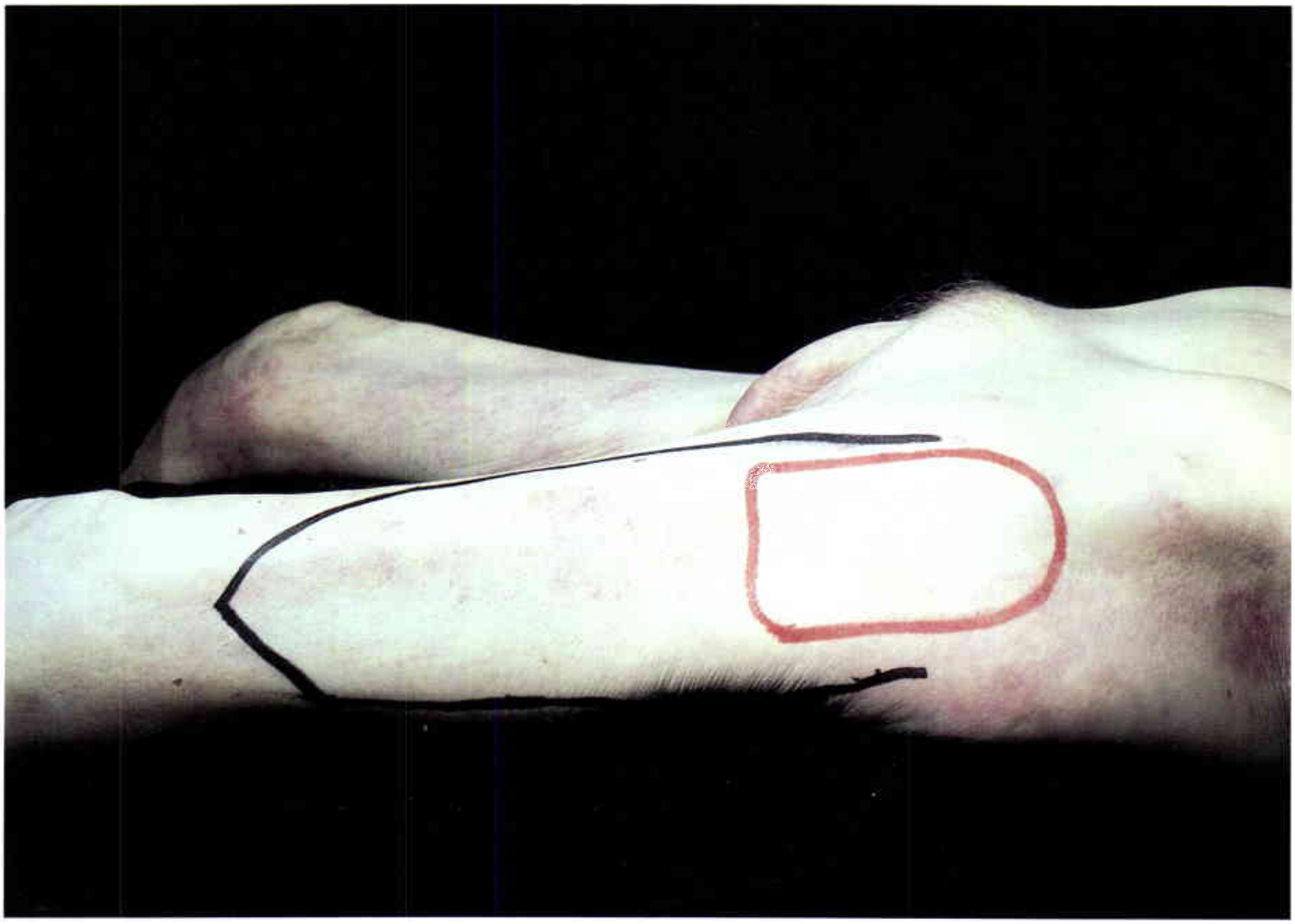
Excessive flap length and improper inset of the flap under tension should be recognized as the most common causes of flap necrosis in this normally robust flap. The flap can sustain a generous amount of either tension or torsion, but the combination of these two stressful events should be avoided. Flap elevation is straightforward, but one must carefully protect the dominant vessels and the lateral femoral cutaneous nerve. Since this sensory nerve enters the anterior border of the TFL flap, the TFL flap must be extended onto the lateral margin of the rectus femoris muscle if the nerve is to be included with the flap. Injury to the lateral femoral cutaneous nerve may result in the well known meralgia paresthetica complex of symptoms. Fortunately, the size and location of the dominant vessels to the flap are predictable.

Prolonged drainage has developed in a small number of patients. In a few cases serous drainage lasted for six or more weeks and was probably caused by a lymphatic fistula or a draining lymphocele. Lateral knee instability is an unusual complication, but it is correctable by the transfer of the rectus femoris tendon into the distal tensor band. It can probably be prevented by attaching the cut distal tensor band into the tendon of the vastus lateralis muscle.

There are very few pitfalls in the mechanics of flap elevation because the plane between the vastus lateralis muscle and the tensor fascia is easily defined. It is possible to injure the dominant vessels when raising the flap as an "island" flap, but their location is consistent. Vascular "spasm" can be caused by traumatic handling of the dominant vessels, and it may lead to partial flap necrosis. Rather than stretching the TFL vessels over the rectus femoris muscle, the origin of the rectus femoris muscle should be divided to increase the upward mobility of the TFL flap. Fortunately, this transection of the rectus femoris muscular origin does not affect the subsequent use of an "island" rectus femoris flap in the same muscle. The donor site is quite acceptable if it can be primarily closed. A skin-grafted donor site is remarkably unesthetic in appearance. Primary closure is facilitated by complete elevation and incision of the fascia lata on the medial aspects of the thigh anteriorly and posteriorly. This fascial "release" advances the skin margins of the remaining thigh skin by an additional five to six centimeters, which can make a critical difference in the donor site closure.



1
The disparity between the small size of the tensor muscle and the surrounding TFL flap dimensions is demonstrated in a model. This donor defect will require a skin graft for closure.



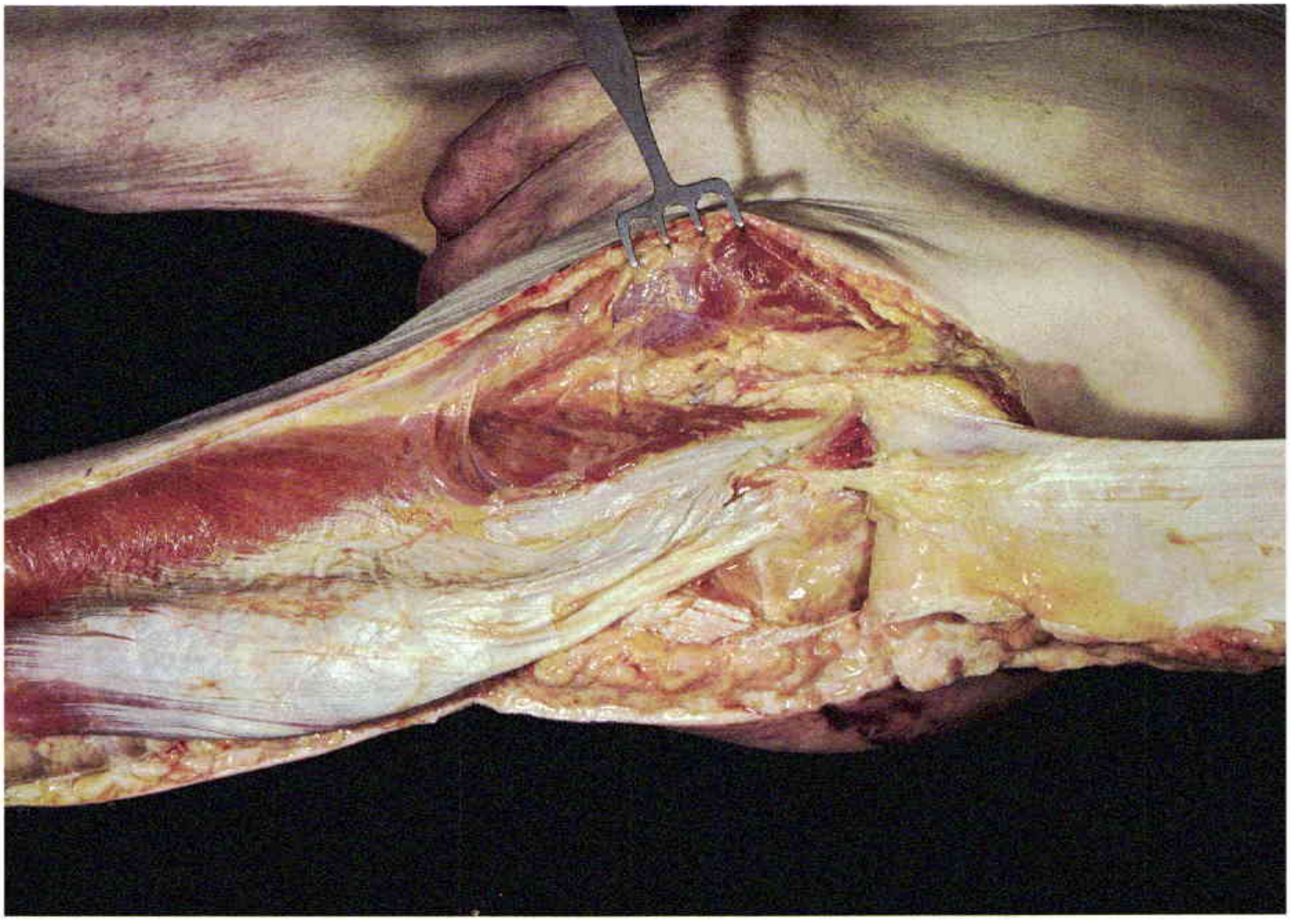
2

A very large TFL flap is outlined in the cadaver. This will create a defect which must be skin grafted. There is a cutaneous vessel which enters the proximal cutaneous "base" of the flap and provides a separate blood supply to the skin. It is unlikely that a longer flap would be reliable because of the relative dominance of the vastus lateralis perforators in the distal one-third of the thigh.

3
The outlined TFL flap extends from the margin of the biceps femoris muscle posteriorly to the midline of the thigh anteriorly. Note that the tensor fascia is deficient distally in the area of the biceps femoris tendon.

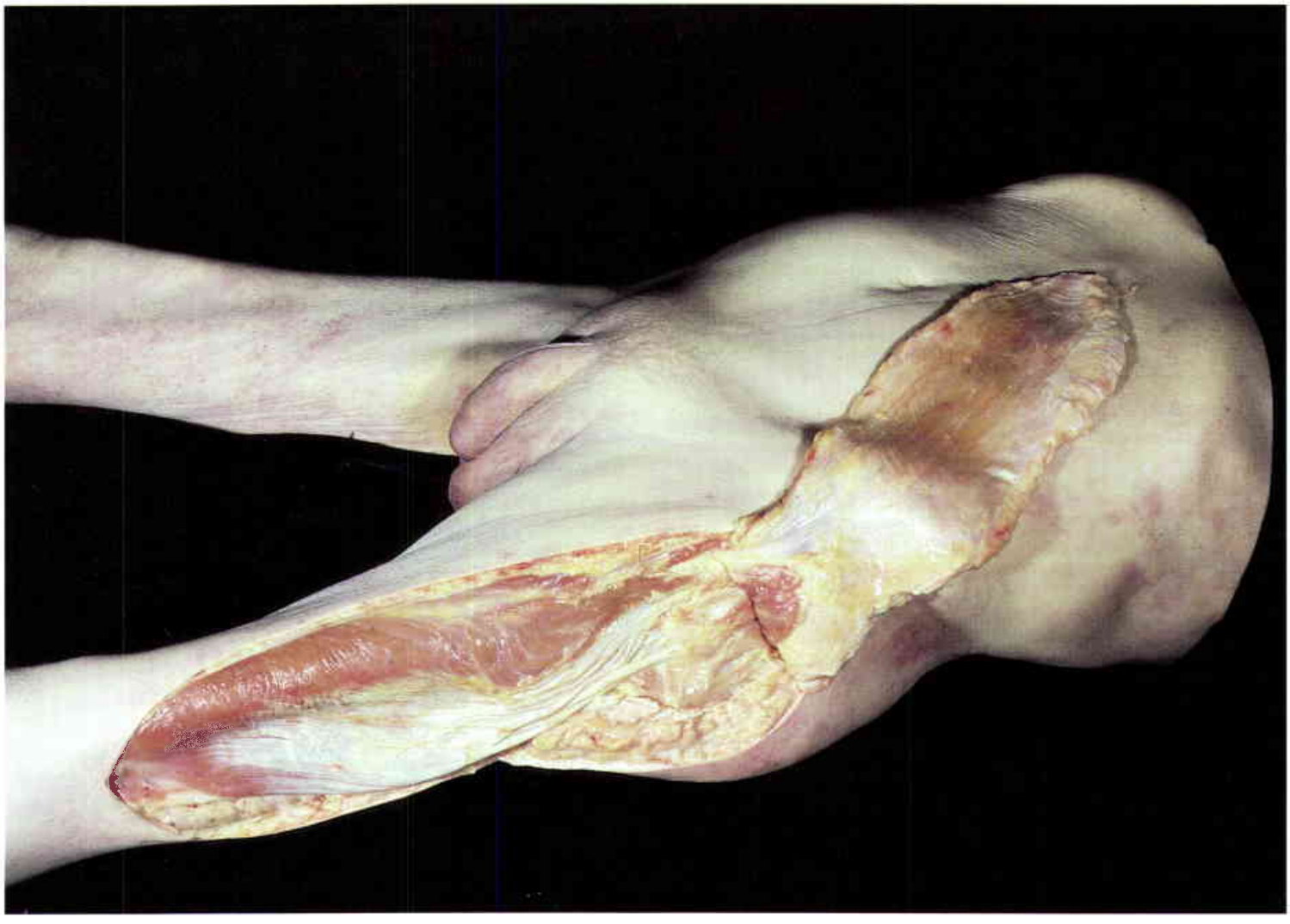
4

The tensor fascia is readily dissected away from the underlying vastus lateralis muscle. In this example the deep fascia was included from the margin of the rectus femoris muscle to the margin of the biceps femoris muscle. The small tensor muscle is partially elevated from its trochanteric origin.



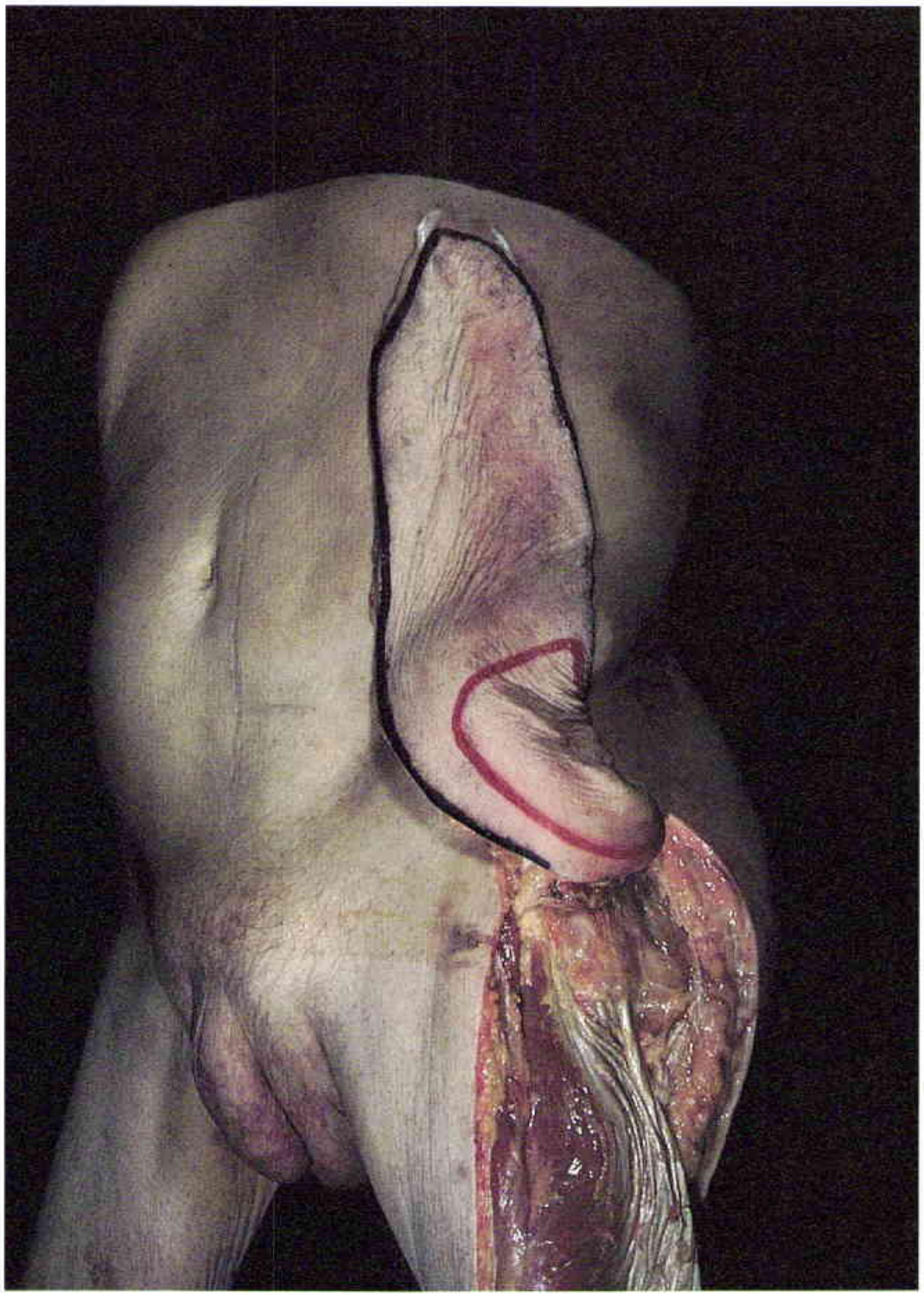
5

The TFL flap has been completely elevated away from the vastus lateralis muscle. The dominant vascular pedicle is seen piercing the proximal tendon of the vastus lateralis muscle and then entering the medial edge of the tensor fascia. The tensor muscle has been partially elevated away from its origin on the greater trochanter. It is safe to remove the tensor muscle from its origin completely since the dominant vasculature is not harmed by this maneuver.

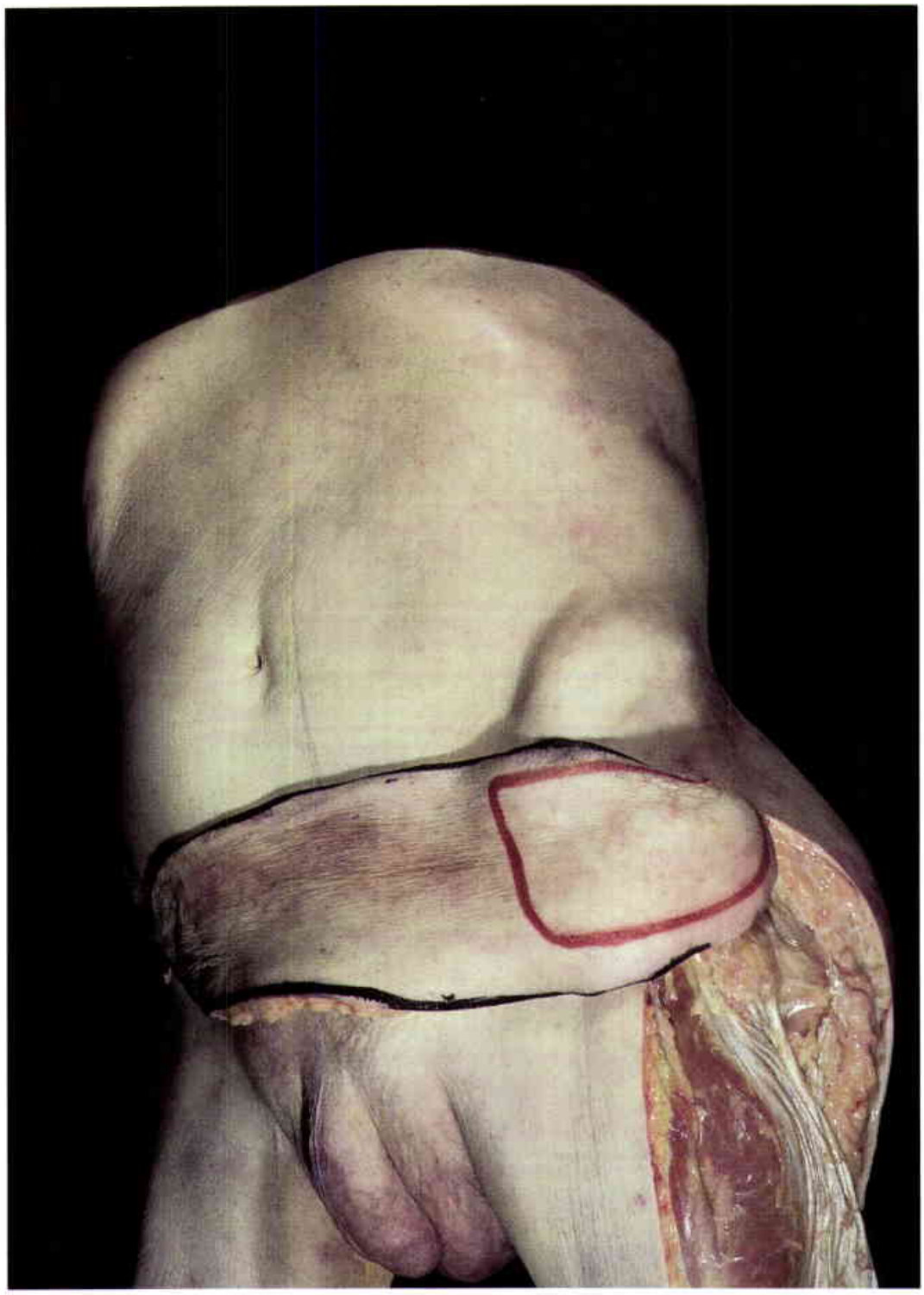


6

The fascial undersurface of the TFL flap is demonstrated. The lateral circumflex femoral vessels are seen entering the tensor muscle just medial to the greater trochanter. These vessels arise from the profunda femoris vessels and then pass beneath the rectus femoris muscle approximately ten centimeters below the inguinal ligament.

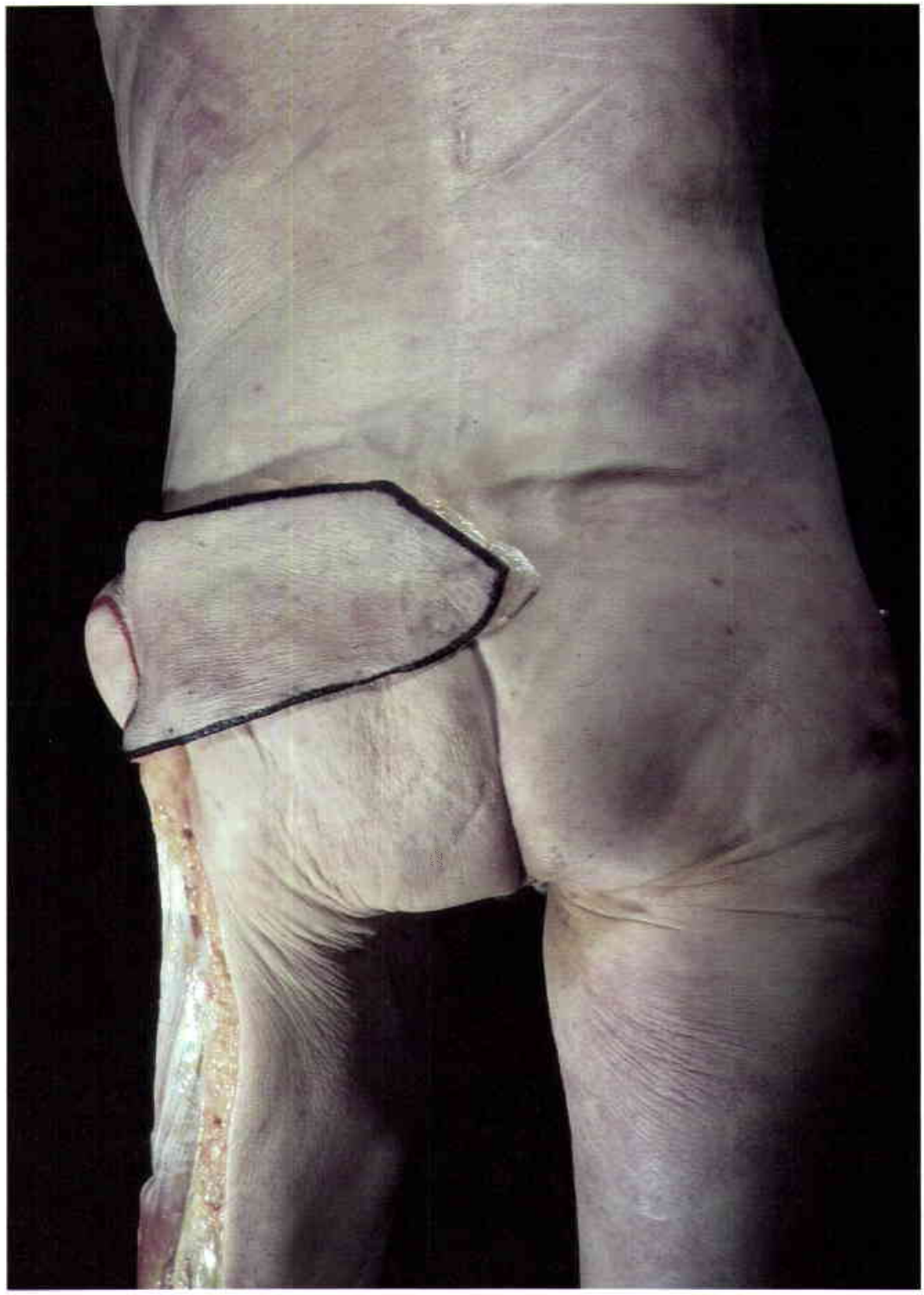


7
The tip of this flap reaches the lower chest wall. Complete elevation of the tensor muscle from the greater trochanter and the creation of a true "island" flap will allow the most distal portion of the tensor fascia to reach the xiphoid.



8
The entire suprapubic area can be resurfaced by the TFL flap.

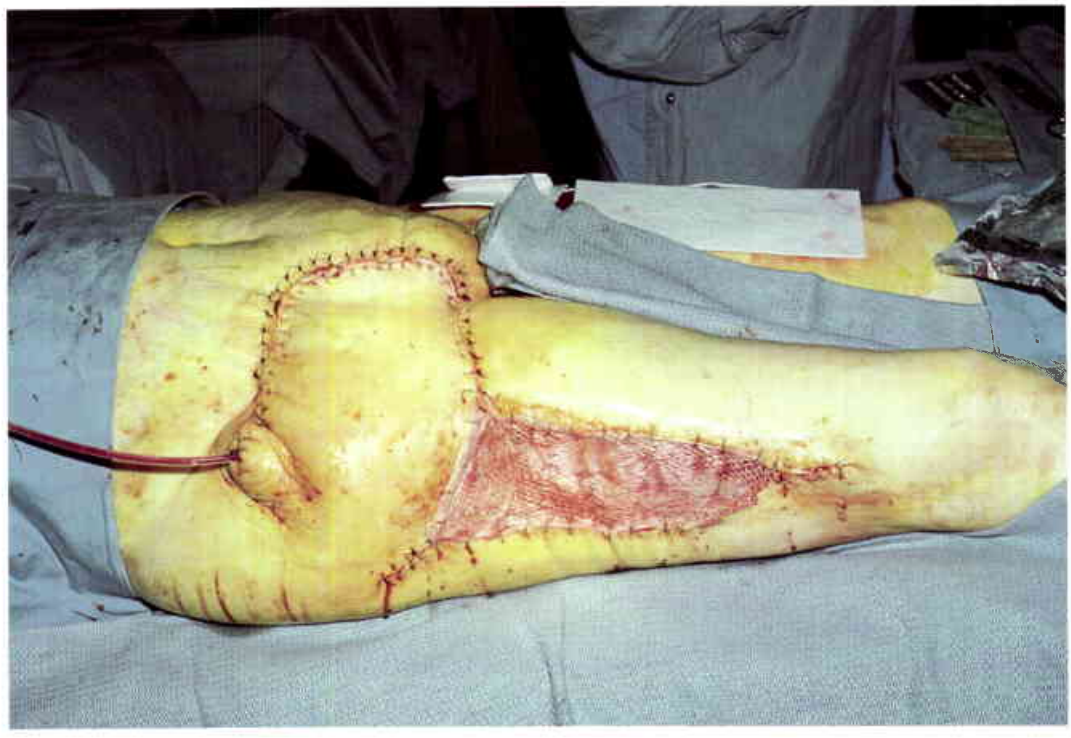
9
Generally the TFL flap will barely cover an ischial defect. This flap has an exceptional posterior excursion.



10
The posterior rotation shows the TFL flap reaching the midsacrum. The long legs of this cadaver provided an unusually lengthy flap.

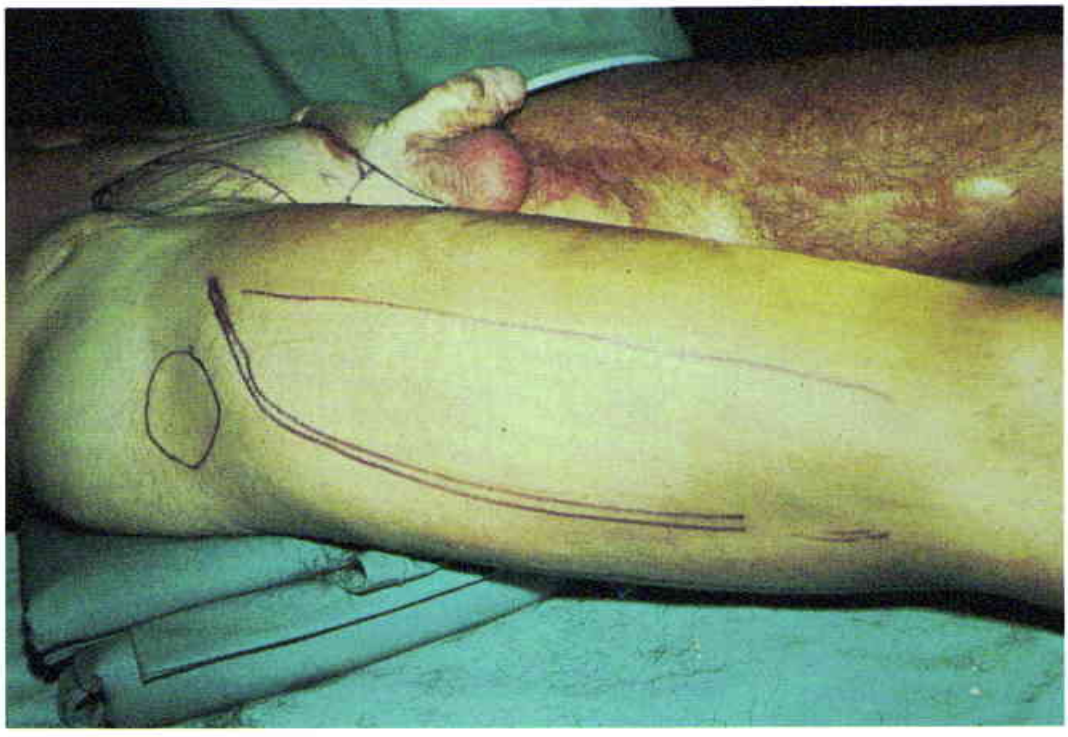
11
Seventy-eight-year-old woman with a carcinoma of the cervix treated with a radical hysterectomy and bilateral groin irradiation. The extensive irradiation ulcer of the right groin has been present for two years. (Case of P.G. Arnold and G. Irons)

12
The irradiation ulcer of the groin and lower abdomen was excised. No tumor was found. A very wide TFL flap is outlined to accommodate the large excisional defect.



13
TFL flap rotated into the defect. The donor site was immediately grafted.

14
Appearance of the flap and donor site at three years. The wound has remained healed.



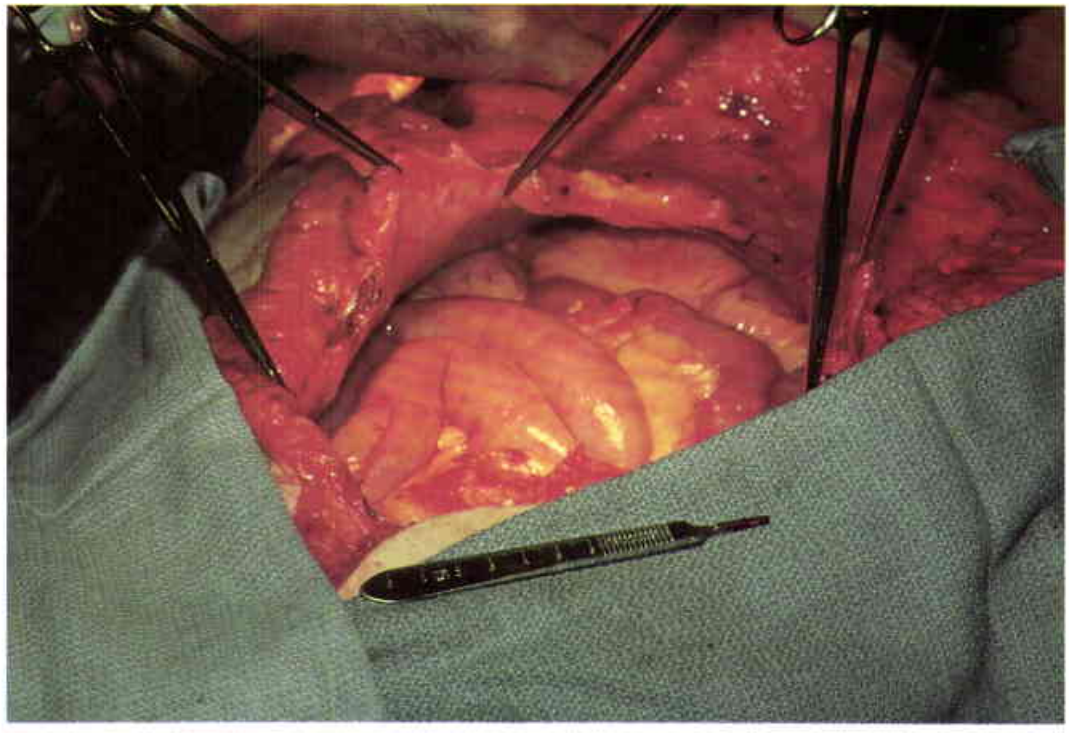
15

This twenty-six-year-old patient sustained a high voltage electrical injury to the perineum, abdomen, and right thigh. The full thickness of the left lower quadrant of the abdominal wall had been lost. A skin graft covered a herniated Marlex® mesh graft in this area. The anterior margin of the TFL flap is outlined. The posterior margin (double line) of the flap will be defined after the ability to close the donor site has been determined. (Case of J.B. McCraw, C.E. Horton, and G. Hoffman)

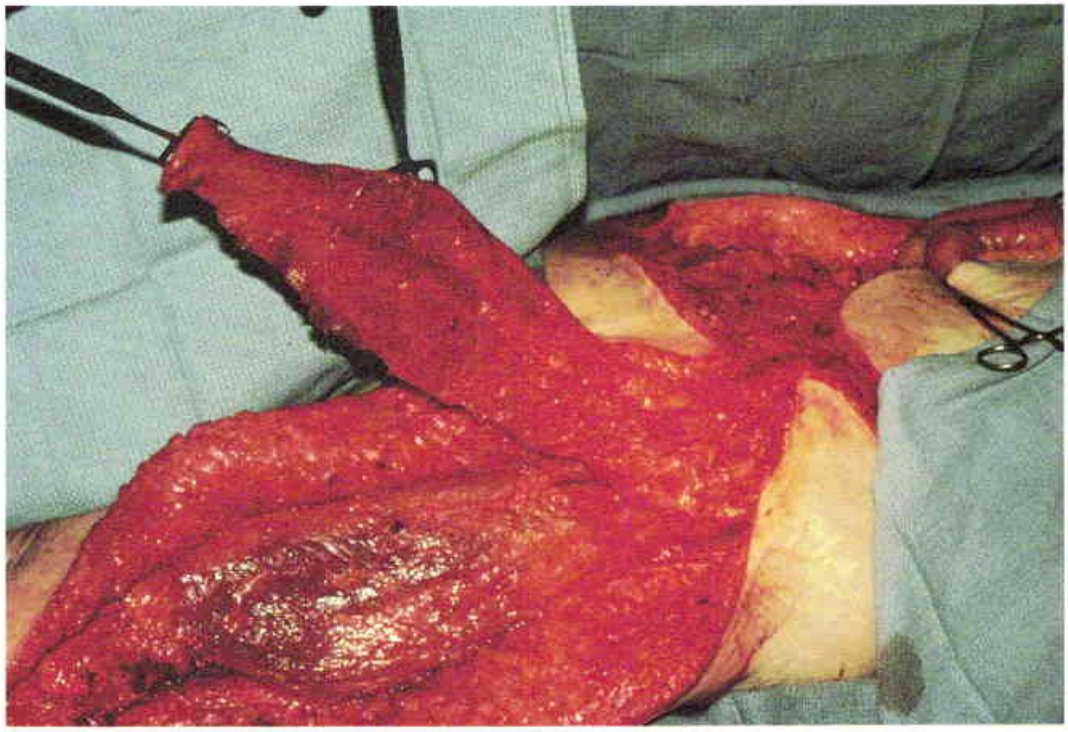
16

The "island" TFL flap is rotated into position. Primary closure of the donor defect was facilitated by anterior and posterior incisions of the deep fascia. The fascia on the undersurface of the TFL flap was used to repair the abdominal wall defect. The cutaneous portion of the flap was used to replace the skin graft of the lower quadrant. The closure of the donor defect was somewhat difficult because the entire medial thigh had previously been skin grafted.

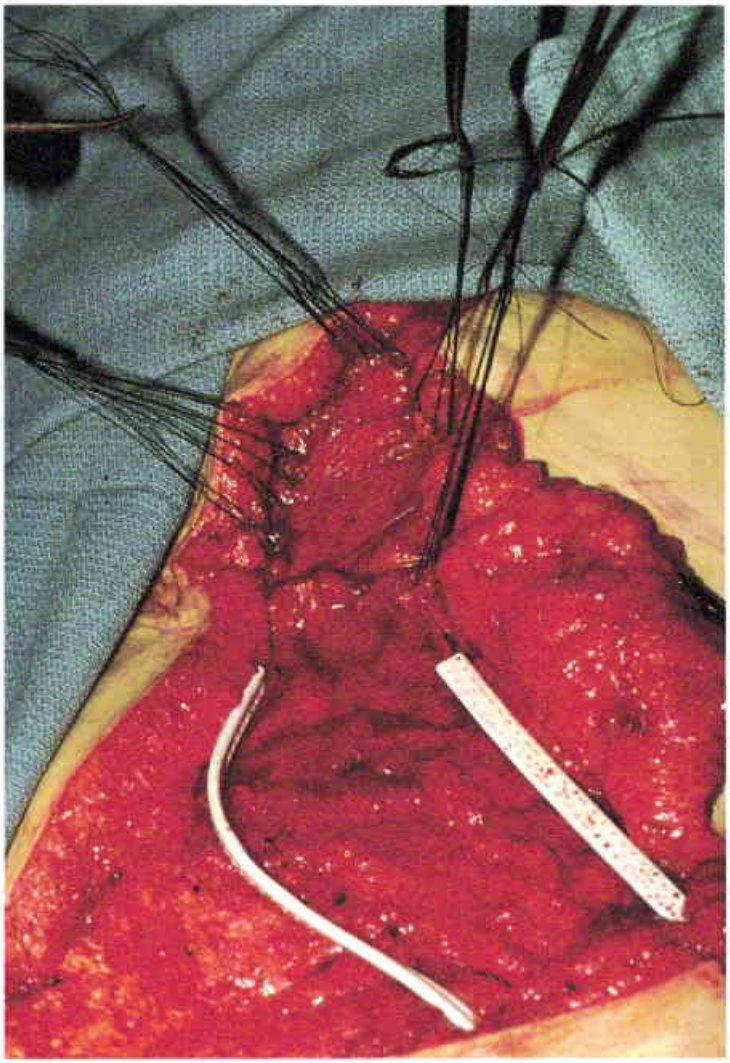
17
This sixty-nine-year-old patient was left with a recurrent abdominal hernia after six abdominal repairs with artificial mesh. The patient had also undergone cobalt irradiation for carcinoma of the cervix, which resulted in an irradiation ulcer in the suprapubic area. (Case of J.B. McCraw and M. Greenspan)



18
The huge abdominal wall defect could not have been closed primarily.



19
A tensor myofascial flap is elevated as a pure "island" flap.

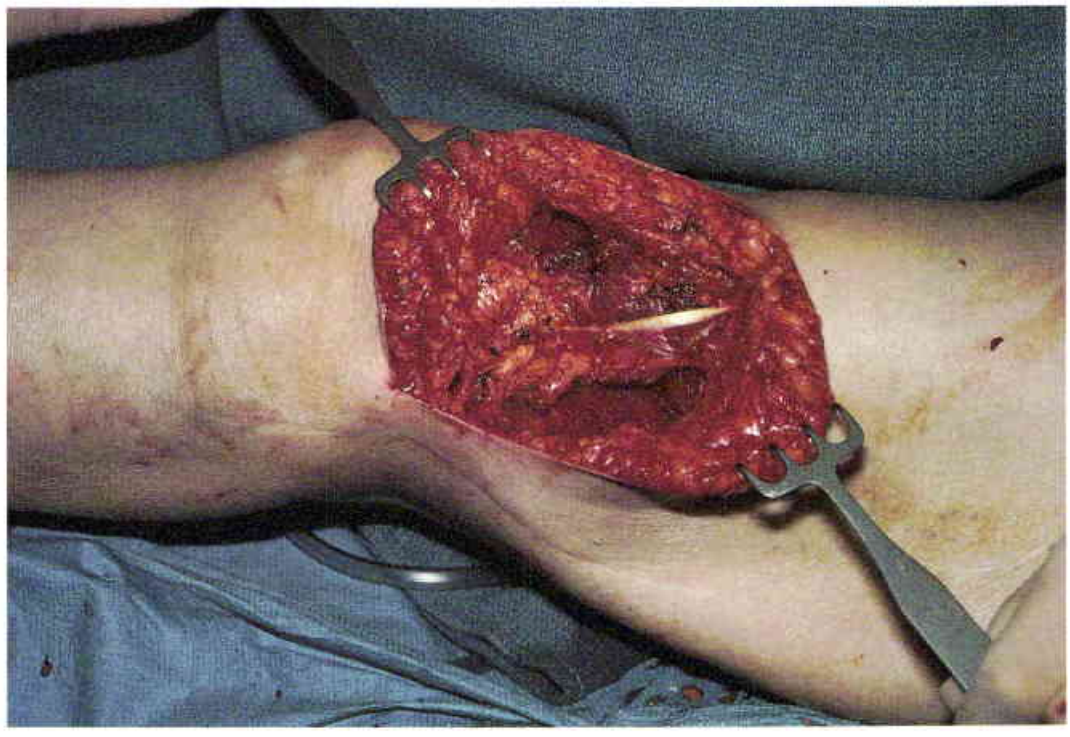


20
The tensor fascia was used as an end-to-end patch, interposed between the two rectus abdominis muscles.

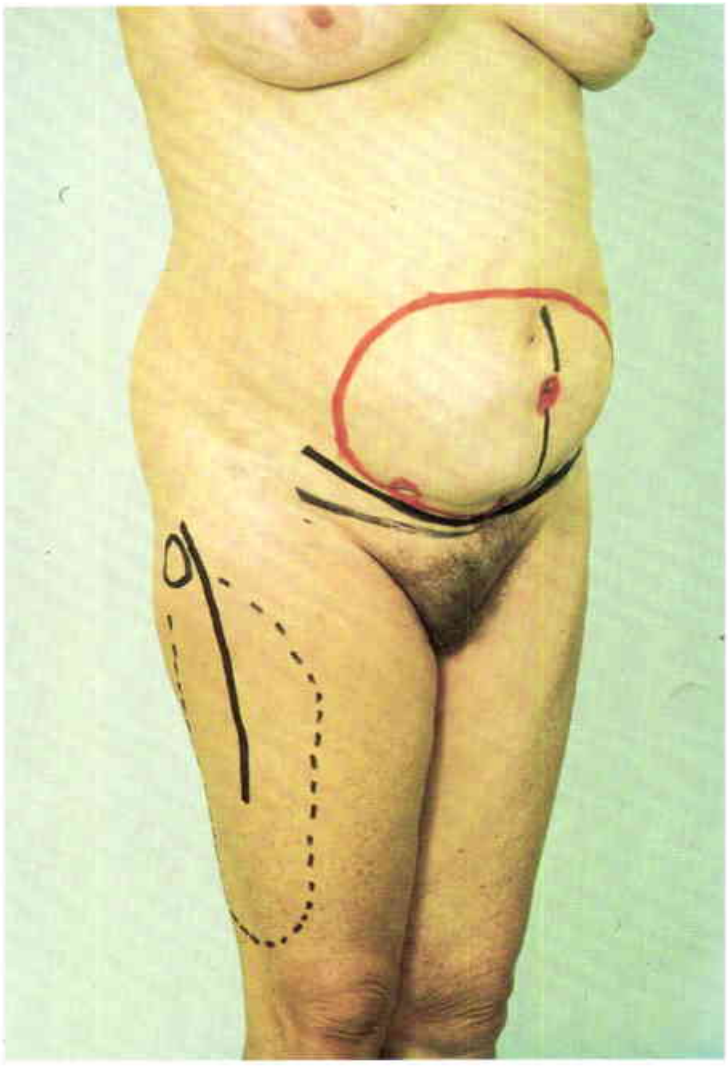
21
Postoperative view demonstrating good abdominal wall stability. This is the same procedure described by Dr. Owen Waagensteen in 1933.

22
Healed donor site.

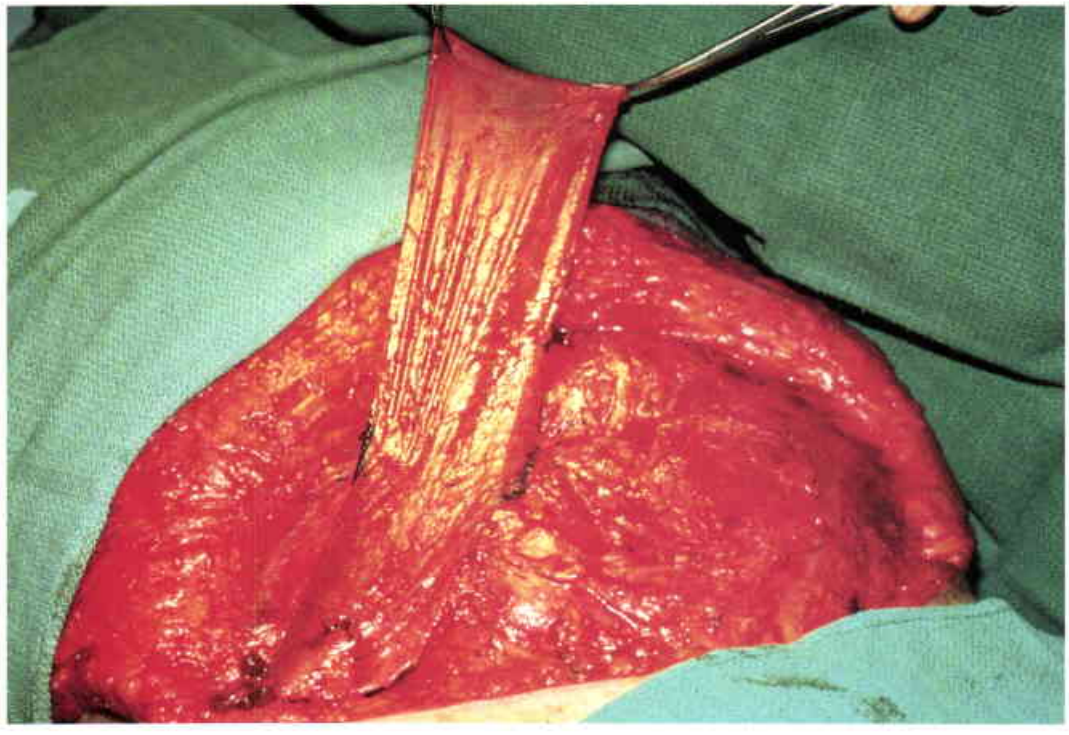
23
Two years later the patient developed left lateral knee instability. The rectus femoris tendon is elevated for transfer into the distal tensor band.



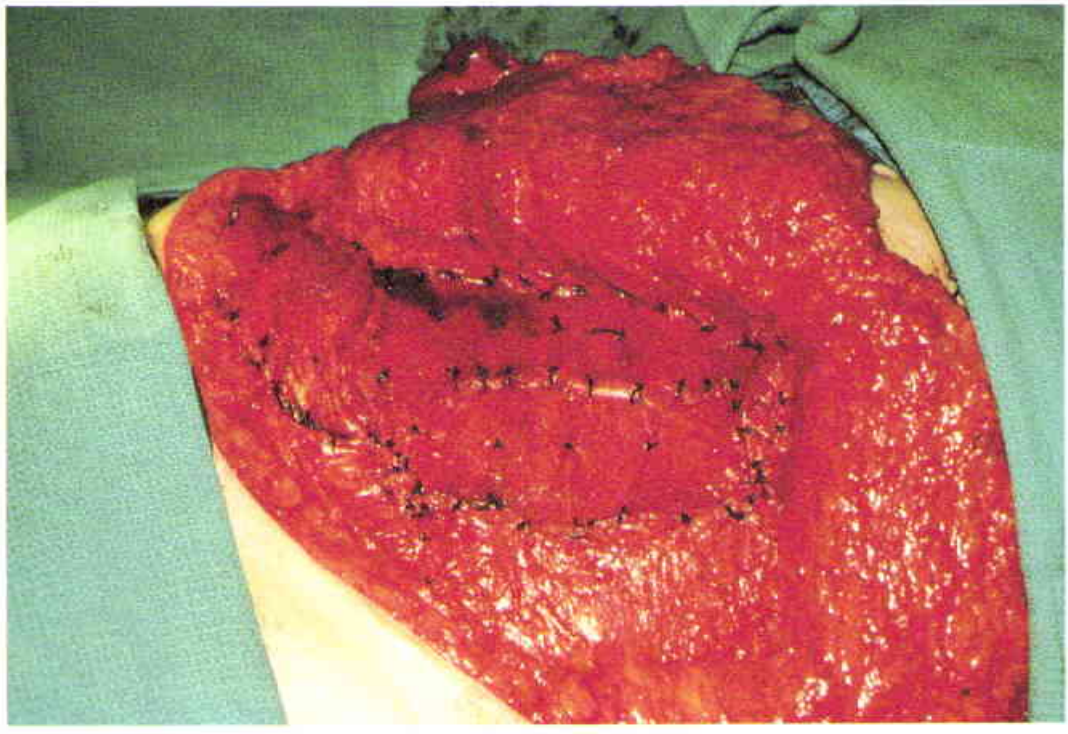
24
The rectus femoris tendon transfer adequately corrected the deficient lateral knee stability that had resulted from the use of the TFL flap.



25
Infected Marlex® mesh repair of an abdominal hernia in a severe asthmatic. A tensor myofascial flap is outlined. (Case of J.B. McCraw and G. Hoffman)



26
"Island" tensor myofascial flap transposed into the abdominal defect.



27
Lateral view of the end-to-end repair of the abdominal fascial defect.

28
Solid abdominal repair at one year. Note the unsightly bulge of the tensor muscle in the right groin. This fullness decreased very little with time and could have been avoided by trimming the tensor muscle initially.

GRACILIS

Achauer, B.M., Braly, P., Berman, M.L., and DiSaia, P.J. "Immediate vaginal reconstruction following resection for malignancy using the gluteal thigh flap." *Gynecol. Oncol.* 19(1): 79, 1984.

Apfelberg, D. and Finseth, F. "Double-muscle gracilis and sartorius myocutaneous flap." *Br. J. Plast. Surg.* 34: 41, 1981.

Atri, S.P. "The treatment of complete rectal prolapses by graciloplasty." *Br. J. Plast. Surg.* 67(6): 431, 1980.

Baek, S.M., Greenstein, A., McElhinney, A.J., and Aufses, A.H., Jr. "The gracilis myocutaneous flap for persistent perineal sinus after proctocolectomy." *Surg. Gynecol. Obstet.* 153(5): 713, 1981.

Bartholdson, L. and Hulten, L. "Repair of persistent perineal sinuses by means of a pedicle flap of musculus gracilis: Case report." *Scand. J. Plast. Reconstr. Surg.* 9(1): 74, 1975.

Becker, D.W., Jr., Massey, F.M., and McCraw, J.B. "Musculocutaneous flaps in reconstructive pelvic surgery." *Obstet. Gynecol.* 54(2): 178, 1979.

Bell, J.G., Weiser, E.B., Metz, P., and Hoskins, W.J. "Gracilis muscle repair of perineal hernia following pelvic exenteration." *Obstet. Gynecol.* 56(3): 377, 1980.

Ben-Hur, N., Gilai, A., Golan, J., Sagher, U., and Issac, M. "Reconstruction of the anal sphincter by gracilis muscle transfer: the value of electromyography in the preoperative assessment and postoperative management of the patient." *Br. J. Plast. Surg.* 33(2): 256, 1980.

Berek, J.S., Hacker, N.F., and Lagasse, L.D. "Vaginal reconstruction performed simultaneously with pelvic exenteration." *Obstet. Gynecol.* 63(3): 318, 1984.

Block, I.R. "Levator ani as substitute puborectalis sling." *Surg. Gynecol. Obstet.* 141: 611, 1975.

Bricker, E.M., Kraybill, W.G., and Lopez, M.J. "Combined reconstruction of the rectum and vagina following irradiation and surgical treatment for clear cell carcinoma." *Surg. Gynecol. Obstet.* 159(2): 166, 1984.

Chantraine, A., Lloyd, K., and Swinyard, C. "The sphincter ani externus in spina bifida and myelomeningocoele." *J. Urol.* 95: 250, 1966.

Cohen, B.E., and Ryan, J.A., Jr. "Gracilis muscle flap for closure of the persistent perineal sinus." *Surg. Gynecol. Obstet.* 148(1): 33, 1979.

Corman, M.L. "Gracilis muscle transposition for anal incontinence: late results." *Br. J. Plast. Surg.* 72 Supp: S21, 1985.

Dibbell, D.G. "Dynamic correction of intractable vaginal prolapse." *Ann. Plast. Surg.* 2: 254, 1979.

Furnas, D.W. and McCraw, J.B. "Resurfacing the genital area." *Clin. Plast. Surg.* 7(2): 235, 1980.

Harii, K., Ohmori, K., and Sekiguchi, J. "The free musculocutaneous flap." *Plast. Reconstr. Surg.* 57(3): 294, 1976.

Harii, K., Ohmori, K., and Torii, S. "Free gracilis muscle transplantation, with microneurovascular anastomoses for the treatment of facial paralysis: A preliminary report." *Plast. Reconstr. Surg.* 57(2): 133, 1976.

Hatch, K.D. "Construction of a neovagina after exenteration using the vulvobulbocavernosus myocutaneous graft." *Obstet. Gynecol.* 63(1): 110, 1984.

Heath, P.M., Woods, J.E., Podratz, K.C., Arnold, P.G., and Irons, G.B., Jr. "Gracilis myocutaneous vaginal reconstruction." *Mayo Clin. Proc.* 59(1): 21, 1984.

Heckler, F.R. "Gracilis myocutaneous and muscle flaps." *Clin. Plast. Surg.* 71(1): 27, 1980.

Heckler, F.R., Dibbell, D.G., and McCraw, J.B. "Successful use of muscle flaps or myocutaneous flaps in patients with sickle cell disease." *Plast. Reconstr. Surg.* 59: 902, 1977.

Hester, T.R., Hill, H.L., and Jurkiewicz, M.J. "One-stage reconstruction of the penis." *Br. J. Plast. Surg.* 31: 279, 1978.

Horton, C.E., McCraw, J.B., Devine, C.J., Jr., and Devine, P.C. "Secondary reconstruction of the genital area." *Urol. Clin. North Am.* 4(1): 133, 1977.

Hoskins, W.J., Park, R.C., Long, R., Artman, L.E., and McMahon, E.B. "Repair of urinary tract fistulas with bulbocavernosus myocutaneous flaps." *Obstet. Gynecol.* 63(4): 588, 1984.

Hurwitz, D.J. "Closure of a large defect of the pelvic cavity by an extended compound myocutaneous flap based on the inferior gluteal artery." *Br. J. Plast. Surg.* 33: 256, 1980.

Hurwitz, D.J., Schwartz, W.M., and Mathes, S.J. "A reliable sensate flap for the closure of buttock and perineal wounds." *Plast. Reconstr. Surg.* 68: 40, 1981.

Kalisman, M. and Sharzer, L.A. "Anal sphincter reconstruction and perineal resurfacing with a gracilis myocutaneous flap." *Dis. Colon Rectum* 24(7): 529, 1981.

Kaplan, I. and Alfandary, H. "The surgical treatment of rectal incontinence by gracilis muscle transplant." *Am. J. Protocol* 22(2): 102, 1971.

Krzeski, T. and Borkowski, A. "Bladder flap for reconstruction of congenital absence of the vagina." *Eur. Urol.* 9(2): 125, 1983.

Labandter, H.P. "The gracilis muscle flap and musculocutaneous flap in the repair of perineal and ischial defects." *Br. J. Plast. Surg.* 33(1): 95, 1980.

Landeen, J.M. and Habal, M.B. "The rejuvenation of the anal sphincteroplasty." *Surg. Gynecol. Obstet.* 149(1): 78, 1979.

Larson, D.L. and Bracken, R.B. "Use of gracilis musculocutaneous flap in urologic cancer surgery." *Urology* 19(2): 148, 1982.

Leguit, P., Jr., van Baal, J.G., and Brummelkamp, W.H. "Gracilis muscle transposition in the treatment of fecal incontinence: Long-term follow-up and evaluation of anal pressure recordings." *Dis. Colon Rectum* 29(1): 1, 1985.

Lesavoy, M.A. "Vaginal reconstruction." *Urol. Clin. North Am.* 12(2): 369, 1985.

Lesavoy, M.A. "Vaginal reconstruction." *Clin. Obstet. Gynecol.* 12(2): 515, 1985.

Lewis, M.I. "Gracilis muscle transplant for the correction of anal incontinence: report of a case." *Dis. Colon Rectum* 15(4): 292, 1972.

Magrina, J.F. and Masterson, B.J. "Vaginal reconstruction in gynecological oncology: a review of techniques." *Obstet. Gynecol. Surg.* 36(1): 1, 1981.

Magrina, J.F. and Masterson, B.J. "Vaginal reconstruction: procedures following radical pelvic surgery." *J. Kans. Med. Soc.* 82(2): 61, 1981.

Manktelow, R. and McKee, N.H. "Free muscle transplantation to provide active finger flexion." *J. Hand Surg.* 3: 416, 1978.

Markland, C. and Hastings, D. "Vaginal reconstruction using cecal and sigmoid bowel segments in transsexual patients." *J. Urol.* 111(2): 217, 1974.

Maruyama, Y., Ohnishi, K., and Hashimura, C. "Functional reconstruction of anal constriction using a gracilis musculocutaneous flap." *Acta. Chir. Plast.* (Prague), 225(2): 76, 1983.

Mathes, S.J. and Albert, B.S. "Advances in muscle and musculocutaneous flaps." *Clin. Plast. Surg.* 7(1): 15, 1980.

McComas, B.C., Reddick, L.P., and Donaldson, R.C. "Gracilis myocutaneous flap reconstruction after radical vulvectomy and posterior exenteration." *J. Tenn. Med. Assoc.* 77(1): 17, 1984.

McCraw, J.B. "Flaps for perineal reconstruction." *Weekly Urology Update* 1978.

McCraw, J.B. "Intraoperative identification of the gracilis muscle for vaginal reconstruction (Letter)." *Plast. Reconstr. Surg.* 65(3): 358, 1980.

McCraw, J.B., Dibbell, D.G., and Carraway, J.H. "Clinical definition of independent myocutaneous vascular territories." *Plast. Reconstr. Surg.* 60: 341, 1977.

McCraw, J.B., Massey, F.M., Shanklin, K.D., and Horton, C.E. "Vaginal reconstruction with gracilis myocutaneous flaps." *Plast. Reconstr. Surg.* 58(2): 176, 1976.

McGregor, J.C. "The gracilis musculocutaneous flap as a method of closure of ischial pressure sores: preliminary report." *Paraplegia* 20(4): 217, 1982.

Morrow, C.P., Lacey, C.G., and Lucas, W.E. "Reconstructive surgery in gynecology cancer employing the gracilis myocutaneous pedicle graft." *Gynecol. Oncol.* 7(2): 176, 1979.

Nahai, F. "Muscle and musculocutaneous flaps in gynecologic surgery." *Clin. Obstet. Gynecol.* 24(4): 1277, 1981.

Nakajima, T., Naide, Y., and Kami, T. "Repair of a prostatomembranous urethral stricture with a gracilis myocutaneous flap." *Br. J. Plast. Surg.* 37(4): 539, 1984.

Ng, H.T., Kan, Y.Y., Chao, K.C., and Yuan, C.C. "Vaginal reconstruction with a sigmoid loop in pelvic exenteration." *Asia Oceania. J. Obstet. Gynaecol.* 10(3): 341, 1984.

Nieves, P.M., Valles, G., Arang'uren, G., and Maldonado, D. "Gracilis muscle transplant for correction of traumatic anal incontinence: report of a case." *Dis. Colon Rectum* 18(4): 349, 1975.

Obrink, A. and Bunne, G. "Gracilis interposition in fistulas following radiotherapy for cervical cancer: A retrospective study." *Urol. Int.* 33(5): 370, 1978.

Orticochea, M. "A new method of total reconstruction of the penis." *Br. J. Plast. Surg.* 25: 347, 1972.

Orticochea, M. "The musculocutaneous flap method: an immediate and heroic substitute for the method of delay." *Br. J. Plast. Surg.* 15: 106, 1972.

Parkask, S. "The use of myocutaneous flaps in block dissections of the groin in cases with gross skin involvement." *Br. J. Plast. Surg.* 35(4): 413, 1982.

Persky, L., Resnick, M., and Despres, J. "Penile reconstruction with gracilis pedicle grafts." *J. Urol.* 129(3): 603, 1983.

Pickrell, K.L., Broadbent, T.R., and Masters, F.S. "Construction of rectal sphincter and restoration of anal continence by transplanting gracilis muscle." *Ann. Surg.* 135: 853, 1952.

Pickrell, K.L., Georgiade, N., Maguire, C., and Crawford, H. "Gracilis muscle transplant for rectal incontinence." *Surgery* 40: 349, 1956.

Pickrell, K.L., Masters, F.W., Georgiade, N., and Horton, C.E. "Rectal sphincter reconstruction, using gracilis muscle transplant." *Plast. Reconstr. Surg.* 13: 46, 1954.

Raffensperger, J. "The gracilis sling for fecal incontinence." *J. Pediatr. Surg.* 14(6): 794, 1979.

Ramos, R.R., Andrews, J.M., and Ferreira, L.M. "A gracilis myocutaneous flap for reconstruction of the scrotum." *Br. J. Plast. Surg.* 37(2): 171, 1984.

Raven, R.W. "Rectal prolapse and incontinence treated by reconstruction of the anorectal sphincters." *Proc. R. Soc. Med.* 63 P Suppl: 94, 1970.

Ryan, J.A., Jr. "Gracilis muscle flap for the persistent perineal sinus of inflammatory bowel disease." *Am. J. Surg.* 148(1): 64: 1984.

Ryan, J.A., Jr., Beebe, H.G., and Gibbons, R.P. "Gracilis muscle flap for closure of rectourethral fistula." *J. Urol.* 122(1): 124, 1979.

Schellhas, H.F. and Fidler, J.P. "Vaginal reconstruction after total pelvic exenteration using a modification of the William's procedure." *Gynecol. Oncol.* 3(1): 21, 1976.

Shubailat, G.F., Ajluni, N.J., and Shahateet, M.A. "Repair of a lower leg defect with an ipsilateral gracilis myocutaneous flap." *Plast. Reconstr. Surg.* 64(4): 560, 1979.

Song, I.C., Cramer, M.S., and Bromberg, B.E. "Primary vaginal reconstruction after pelvic exenteration." *Plast. Reconstr. Surg.* 51(5): 509, 1973.

Song, R., Wang, X., and Zhou, G. "Reconstruction of the vagina with sensory function." *Clin. Plast. Surg.* 9(1): 105, 1982.

Sorosky, J.I., Bass, D.M., Curry, S.L., and Hewett, W.J. "Gracilis myocutaneous flap as a life-saving procedure in control of necrosis following radiotherapy and radical surgery for pelvic malignancy." *Gynecol. Oncol.* 13(3): 405, 1982.

Venugopalan, S. "Repair of midline abdominal incisional hernia by gracilis muscle transfer." *Br. J. Plast. Surg.* 33(1): 43, 1980.

Wee, J.T. and Wong, C.S. "Functional and sphincter reconstruction with the gracilis muscle after abdominoperineal resection (letter)." *Lancet* 2(8361): 1245, 1983.

Westfall, C.T. and Keller, H.B. "Scrotal reconstruction utilizing bilateral gracilis myocutaneous flaps." *Plast. Reconstr. Surg.* 68(6): 945, 1981.

Wheeless, C.R., McGibbon, B., Dorsey, J.H., et al. "Gracilis myocutaneous flap in reconstruction of the vulva and female perineum." *Obstet. Gynecol.* 54: 97, 1979.

Wingate, G.B. and Friedland, J.A. "Repair of ischial pressure ulcers with gracilis myocutaneous island flaps." *Plast. Reconstr. Surg.* 62(2): 245, 1978.

Woods, J.E. and Beard, R.W., Jr. "Reconstruction of nonhealing perineal wounds with gracilis muscle flaps." *Ann. Plast. Surg.* 11(6): 513, 1983.