CURRENT SURGICAL PROCEDURES FOR LENGTHENING OF THE TRICEPS SURAE AND ITS COMPONENTS

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Introduction

Ankle equinus is now widely accepted as a deforming pathological force in the lower extremity. The author has previously discussed the deformity in detail including the anatomy, biomechanics, definition, etiology, classification, associated pathology, conservative treatment, surgical treatment, and postoperative care and complications (1). The purpose of this paper is to discuss the current surgical procedures utilized for the correction of the muscular forms of ankle equinus. The surgical procedures are based upon the etiologic type of equinus, and recognition of the type is essential to proper procedural selection.

Etiologic Classification

Ankle equinus can be classified into muscular, osseous, and combination forms which can be further subdivided into etiologic type (Fig. 1). The muscular forms of ankle equinus includes two etiologic types—gastrocnemius equinus and gastrosoleus equinus. Since these two etiologic types are muscular, one must determine whether they are spastic or nonspastic in nature. Thus, four etiologic subtypes exist—spastic gastrocnemius equinus, nonspastic gastrocnemius equinus, spastic gastrosoleus equinus, and nonspastic gastrosoleus equinus.

The earliest surgical procedures were oriented towards the correction of the spastic types of muscular equinus.

Muscular Forms
- Gastrocnemius Equinus*
  - Spastic
  - Nonspastic
- Gastrosoleus Equinus*
  - Spastic
  - Nonspastic

Osseous Forms
- Talotibial Exostoses*
  - Anterior
  - Posterior
  - Other
- Pseudoequinus*

Combination Forms*

* = Five major etiologic types

Fig. 1. Etiologic Types of Ankle Equinus

Recent podiatric literature has recognized the existence of nonspastic muscular equinus. Indeed, we now recognize nonspastic muscular equinus as the most common etiologic type of ankle equinus. Nonspastic gastrocnemius and nonspastic gastrosoleus equinus are frequent pathological conditions leading to severe compensatory changes within the foot or leg if left untreated.

Surgical correction of the muscular form of ankle equinus is oriented toward the particular etiologic subtype involved. Differentiation of these four subtypes is a two-step process.

First, gastrocnemius equinus must be differentiated from gastrosoleus equinus. This is accomplished via the Silfverskiold test. One must begin by identifying the presence of ankle equinus by placing the patient in a supine position and dorsiflexing the foot upon the leg at the ankle. If an ankle equinus deformity is identified, then one should flex the knee ninety degrees and again check for ankle equinus. This is the Silfverskiold test and it takes advantage of the gastrocnemius and plantaris muscles' origin above the knee joint. If with the knee flexed (relaxing the gastrocnemius and plantaris) there is adequate dorsiflexion at the ankle joint then the deformity is due to the gastrocnemius and plantaris muscles. If no increase or insufficient increase in ankle joint dorsiflexion is obtained then one must differentiate gastrosoleus equinus from osseous talotibial ankle equinus (Fig. 2) (1).

Once the presence of gastrocnemius or gastrosoleus equinus has been identified then one must determine whether the involved musculature is spastic or nonspastic. A thorough history combined with neurological evaluation will usually identify any spasticity which may be present. If desired or if any questions remain, a consultation with a neurologist may be advisable. Spasticity of the posterior crural musculature is most commonly associated with the pyramidal-spastic type of cerebral palsy. This spasticity must be differentiated from other pathological extrapyramidal causes of muscular change (Figure 3) (2).

After proper examination and identification of the etiologic type of muscular ankle equinus, one may more easily select the appropriate surgical procedure.

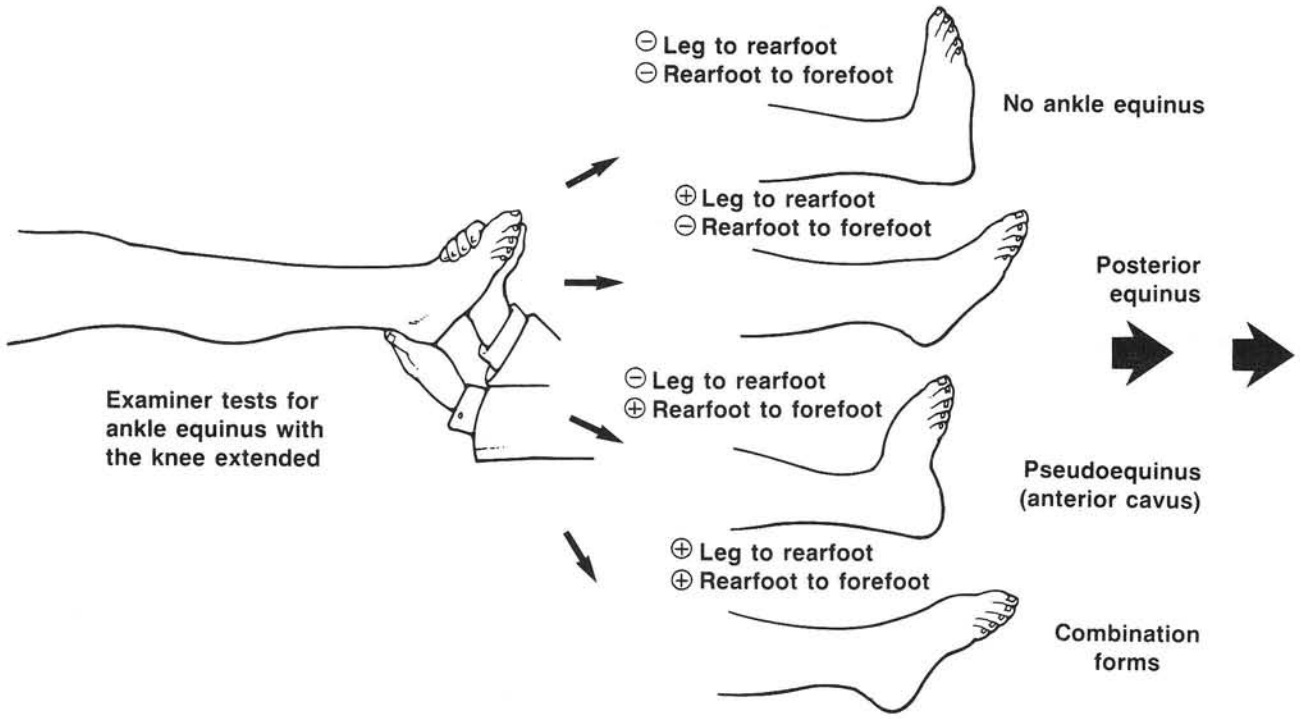


Fig. 2. Step-wise approach to diagnosis of etiologic types of ankle equinus. (Reproduced with permission from Downey MS: Ankle equinus. In McGlamry ED(ed): *Comprehensive Textbook of Foot Surgery,* Vol 1. Baltimore, Williams & Wilkins, 1987, pp 378-379.)

	Extrapyramidal	Pyramidal
Muscle power	Decreased	Decreased
Muscle tone	Rigid	Spastic
Muscle atrophy	Absent	Minimal
Fasciculations	Absent	Absent
Deep reflexes	Normal or variable	Hyperactive
Superficial reflexes	Normal or increased	Diminished
Babinski sign	No	Yes
Sensation	Intact	May be diminished
Abnormal movements	Present	None

Fig. 3. Clinical differentiation of extrapyramidal and pyramidal tract disorders. (Adapted from Tachdjian MO: *The Child's Foot,* Philadelphia, WB Saunders, 1985, p. 354.)

Surgical Procedures

Surgical correction is attempted when conservative measures have failed or when conservative treatment would allow significant pathological changes within the lower extremity to continue. In other words, surgical treatment should not be delayed if, in exhausting all conservative means, one allows compensatory changes to occur which will produce additional deformity. The appropriate surgical procedure is selected based upon the etiologic type or subtype of muscular ankle equinus—nonspastic gastrocnemius equinus, nonspastic gastrosoleus equinus, and spastic gastrocnemius or spastic gastrosoleus equinus.

Nonspastic Gastrocnemius Equinus

This type of muscular ankle equinus has been only recently reported. Indeed, this may be the most common etiologic type of ankle equinus.

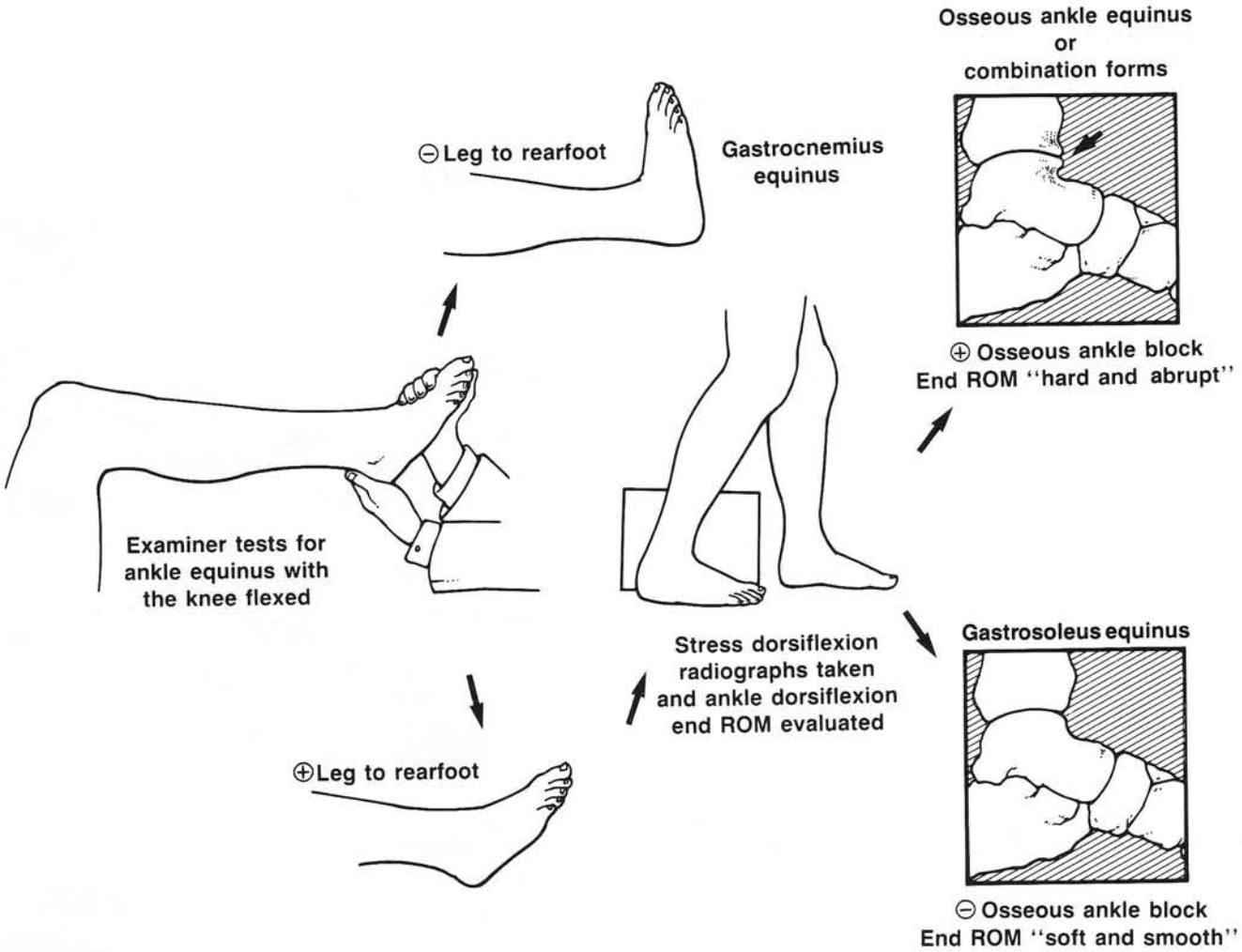


Fig. 2. (cont'd.)

Many different procedures have been described for the treatment of gastrocnemius equinus (1). The distal recession of the gastrocnemius aponeurosis is generally associated with less disability and complications. The tongue-in-groove recession as initially described by Baker (3) and popularized by McGlamry (4) is an example of such a distal recession (Fig. 4). The procedure is commonly used within the profession and is associated with consistently satisfactory results.

Technique—Distal Gastrocnemius Recession

The procedure is most easily performed with the patient under general anesthesia and in the prone position. A mid-thigh pneumatic tourniquet or local anesthetic with a small concentration of epinephrine (e.g., 0.25% Bupivicaine with epinephrine 1:200,000) may be used to aid in hemostasis.

The skin incision is approximately five to eight centimeters in length and placed just medial to the midline of the leg extending from the myotendinous junction of the gastrocnemius muscle distally. The incision is carried deep bluntly with hemostasis obtained as necessary. Care should be taken to avoid the sural nerve or lesser saphenous vein which may be occasionally identified in the lateral portion of the incision. Blunt dissection is continued until the deep fascia is visualized. The subcutaneous tissue and neurovascular structures can then easily be retracted. The deep fascia and paratenon are incised sharply and reflected. The aponeurosis is then visualized and its medial and lateral borders identified. By manipulating the ankle joint, one is able to surgically observe and bring considerable length of the aponeurosis into a relatively small incision.

Thus, with the ankle joint held in the plantarflexed position, the medial and lateral one-thirds of the gastrocnemius aponeurosis are incised (Fig. 5A). Care must be taken to avoid cutting the underlying soleus muscle which may increase postoperative bleeding and edema. Generally, the plantaris will be identified when making the medial aponeurotic cut and it should be lengthened or a section of it excised. The ankle joint is then dorsiflexed with the knee fully extended and the central one-third of the aponeurotic fibers incised (Fig. 5B). The knee must be fully extended to allow the

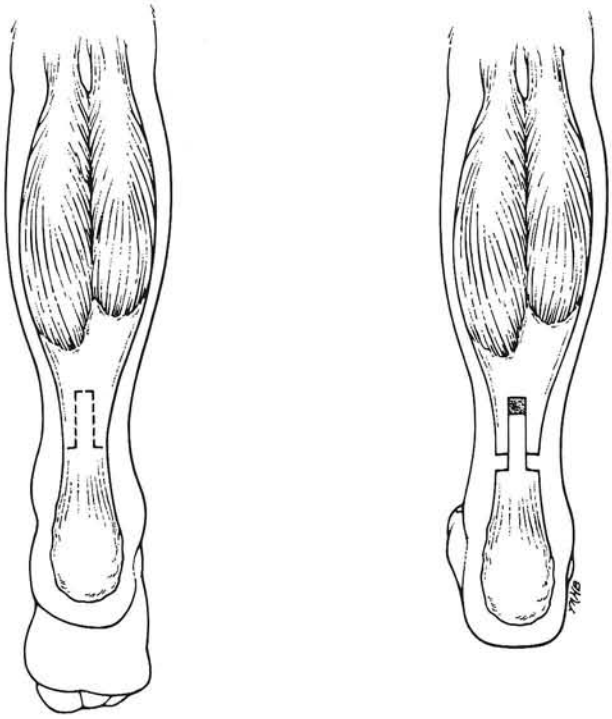


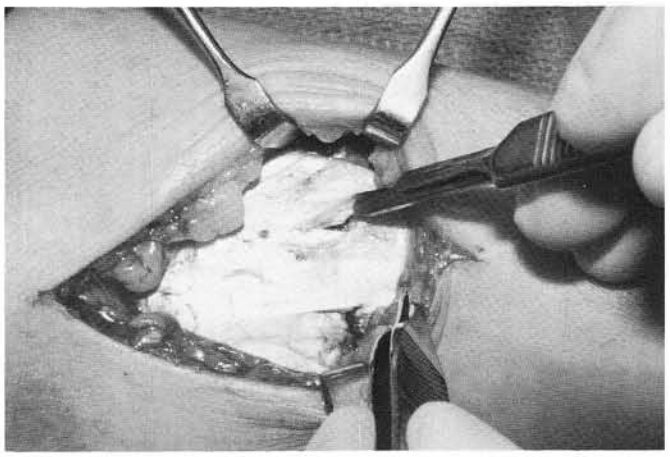
Fig. 4. Distal "tongue-in-groove" gastrocnemius recession as described by Baker (3). (Reproduced with permission from Downey MS: Ankle equinus. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Vol 1. Baltimore, Williams & Wilkins, 1987, p 388.)

gastrocnemius muscle and aponeurosis to be fully loaded and under tension when the ankle is dorsiflexed. The aponeurosis should then be seen to "slide" to a lengthened position (Fig. 5C). If necessary, the incisions in the aponeurosis may be lengthened to create an increase in "sliding" or length. In some cases, the central soleus aponeurosis will be tight. It can be identified in the central gastrocnemius aponeurotic cut and be sectioned if desired.

In some instances it may be preferable to reverse the cuts—i.e., the medial and lateral one-thirds of the aponeurosis are sectioned proximally and the central one-third sectioned distally. This may be the preferred orientation if the aponeurosis is very narrow distally. However, it can result in selective weakening of the medial head of the gastrocnemius muscle due to the orientation of the cuts and their relationship to the torque of the aponeurotic fibers.

Once adequate length has been obtained, the aponeurosis is sutured in its corrected position utilizing a 3-0 absorbable or nonabsorbable suture. The deep fascia and paratenon are closed with a 3-0 absorbable suture. The superficial fascia and skin are closed with running sutures of 4-0 and 6-0 absorbable suture, respectively. The wound is reinforced with steri-strips and a saline moistened sponge and dry sterile dressing applied. A below-knee cast is applied with the knee fully extended and the foot held at ninety

A



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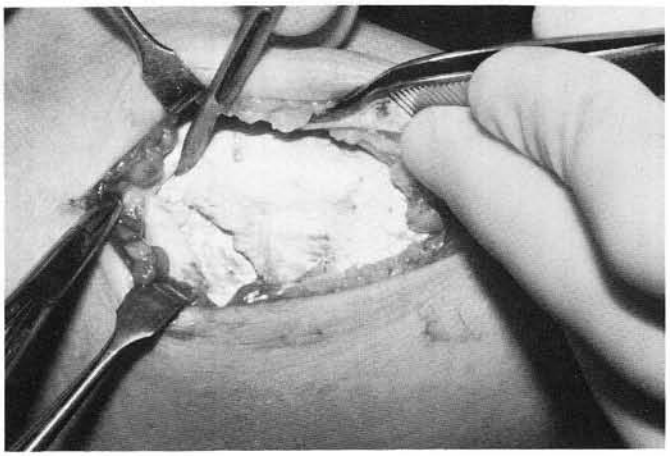

C

Fig. 5. A-C. Surgical demonstration of "tongue-in-groove" cuts. (Reproduced with permission from Downey MS: Ankle Equinus. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Vol 1, Baltimore, Williams & Wilkins, 1987, p 390.)

degrees in relation to the leg. If desired, the cast may be a temporary one with the permanent cast applied after satisfactory postoperative wound appearance has been observed (e.g., three days postoperative).

The patient is maintained in the cast for three and one-half to six weeks postoperatively. The patient in most instances will be allowed to ambulate on the cast. If adjunctive procedures are performed necessitating a non-weightbearing attitude, then crutches are dispensed and the patient is gait trained. After cast removal, the patient is instructed in passive and active range of motion exercises. Running and strenuous physical activity are not allowed for four to six additional weeks or until the gastrocnemius muscle's strength returns.

Nonspastic Gastrosoleus Equinus

Many procedures have been described for the correction of the gastrosoleus equinus deformity (1). Mistakenly, many authors and surgeons have just one surgical procedure for the correction of all types of muscular ankle equinus. It is generally a procedure to lengthen the tendo Achillis. Although such procedures may correct all types of muscular ankle equinus, they are also frequently associated with greater disability, greater chance of complications including recurrence, and with a higher incidence of undercorrection and overcorrection. This is especially true when the procedures are used for the etiologic subtypes of equinus for which they are not indicated. The tendo Achillis lengthening procedure is best suited for the nonspastic gastrosoleus equinus deformity, but may in some instances, be utilized for spastic gastrosoleus equinus as well. It must be remembered that the term gastrosoleus equinus includes any muscular or soft tissue structures in the posterior leg which might be limiting ankle dorsiflexion. Frequently, posterior ankle capsular release or release of other soft tissues will be necessary adjunctive procedures.

The open z-plasty lengthening of the tendo Achillis is preferable to those done percutaneously. Percutaneous tendo Achillis lengthening is associated with a greater likelihood of undercorrection or overcorrection. It is very difficult to visualize and accurately divide the appropriate tendinous fibers through percutaneous incisions. The open z-plasty lengthening can be performed in the frontal or sagittal planes. In most instances, the frontal plane orientation is preferred as it more easily maintains the tendon's contour (Fig. 6).

Technique — Open Frontal Plane Z-plasty Tendo Achillis Lengthening

Like the distal gastrocnemius recession, the procedure is most easily performed with the patient under general anesthesia and in the prone position. A mid-thigh pneumatic tourniquet or local anesthetic containing a small amount of epinephrine may be used to assist hemostasis.

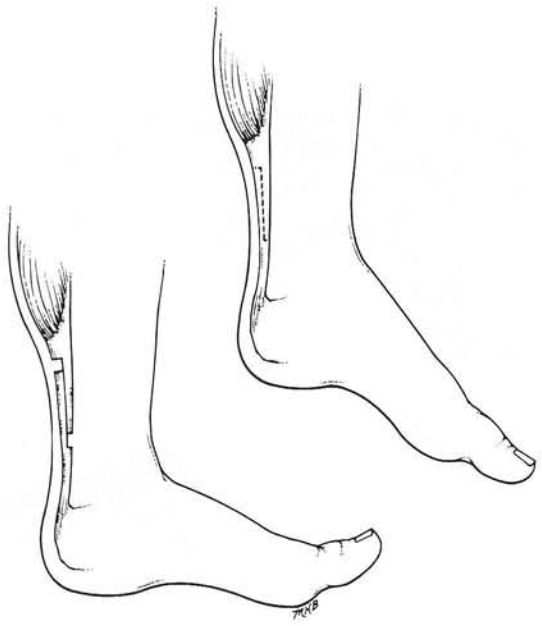

Fig. 6. Frontal plane Z-plasty lengthening of tendo Achillis. (Reproduced with permission from Downey MS: Ankle equinus. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Vol 1. Baltimore, Williams & Wilkins, 1987, p 397.)

The incision is five to ten centimeters in length and placed medial to the midline over the distal portion of the tendo Achillis. The incision is deepened to the deep fascia with small vessels coagulated as necessary. The sural nerve and lesser saphenous vein are avoided and retracted laterally if visualized. The deep fascia and paratenon are then incised sharply and retracted. The tendo Achillis is then visualized.

The tendo Achillis is sectioned in the frontal plane (Fig. 7A). Utilizing sharp dissection the tendon is bisected and then exited proximally in a posterior direction (Fig. 7B). The anterior portion of the tendon is then sectioned distally and the tendon ends retracted (Fig. 7C). After the z-shaped cut is completed, ankle dorsiflexion with the knee fully extended is performed. Any other tight soft tissue structures (e.g., posterior ankle joint capsule) which limit adequate ankle dorsiflexion are then identified and corrected.

When satisfactory dorsiflexion of the ankle joint has been achieved, the tendon is reapproximated in its lengthened position utilizing combinations of absorbable and/or nonabsorbable suture. The deep fascia and paratenon are reapproximated together with 3-0 absorbable suture. The superficial fascia is reapproximated with 4-0 absorbable suture, and the skin with 6-0 absorbable suture. Steri-strips, a saline moistened sponge, a dry sterile dressing, and a below-knee cast are then applied.

Postoperatively, the patient is maintained in a cast for six weeks. Exercises are begun after cast removal and running discouraged until full muscle strength is restored.

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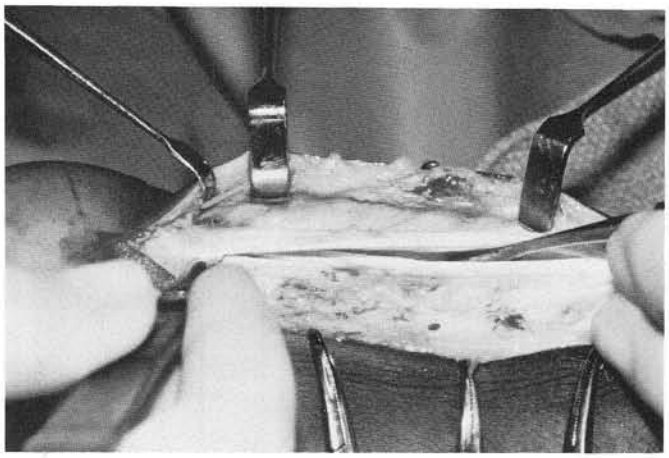

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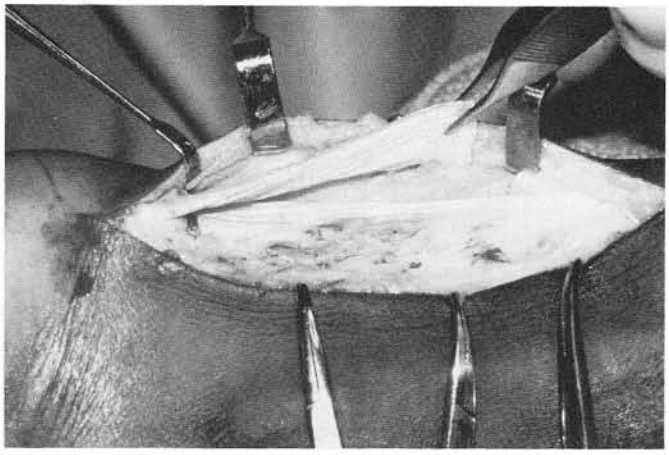

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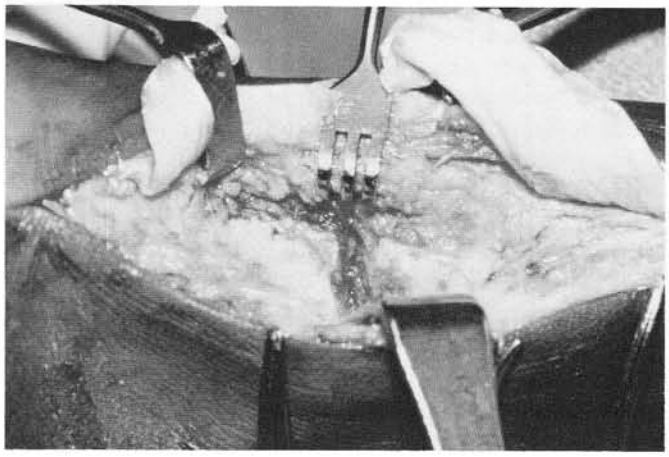

Fig. 7. A-C. Surgical demonstration of frontal plane Z-plasty tendo Achillis lengthening.

Spastic Gastrocnemius and Gastrosoleus Equinus

As was stated earlier, most of the procedures for the correction of the ankle equinus deformity were initially described for the correction of spastic muscular equinus. Some of the earlier procedures (e.g, selective neurectomies or proximal recessions) were fraught with complications and recurrence.

The anterior advancement of the tendo Achillis, as popularized by Murphy, is the author's current procedure of choice for the correction of spastic gastrocnemius and spastic gastrosoleus equinus. The procedure permits an alteration of the functional influence of the tendo Achillis at the ankle joint. It shortens the lever arm of the tendo Achillis at the ankle joint decreasing the power of the triceps surae to affect toe-off (Fig. 8).

Technique—Anterior Advancement of the Tendo Achillis

The procedure is performed with the patient under general anesthesia and in the prone position. General anesthesia and muscle relaxants are usually necessary to eliminate the muscle spasm present. A mid-thigh pneumatic tourniquet is utilized.

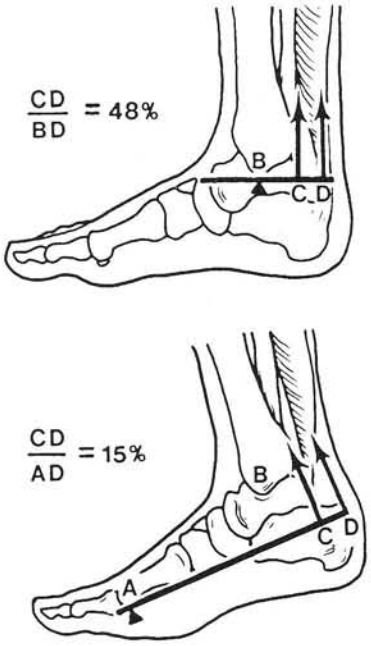

Fig. 8. Principle of tendo Achillis advancement. Theoretically, advancing tendo Achillis from D to C weakens triceps surae power at ankle joint by about 48% by shortening lever arm (BD). At same time, muscle's power at MTPJs is only weakened by about 15% as shortening (DC) is very small compared to longer lever arm (AD). (Reproduced with permission from Downey MS: Ankle equinus. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Vol 1. Baltimore, Williams & Wilkins, 1987, p 392.)

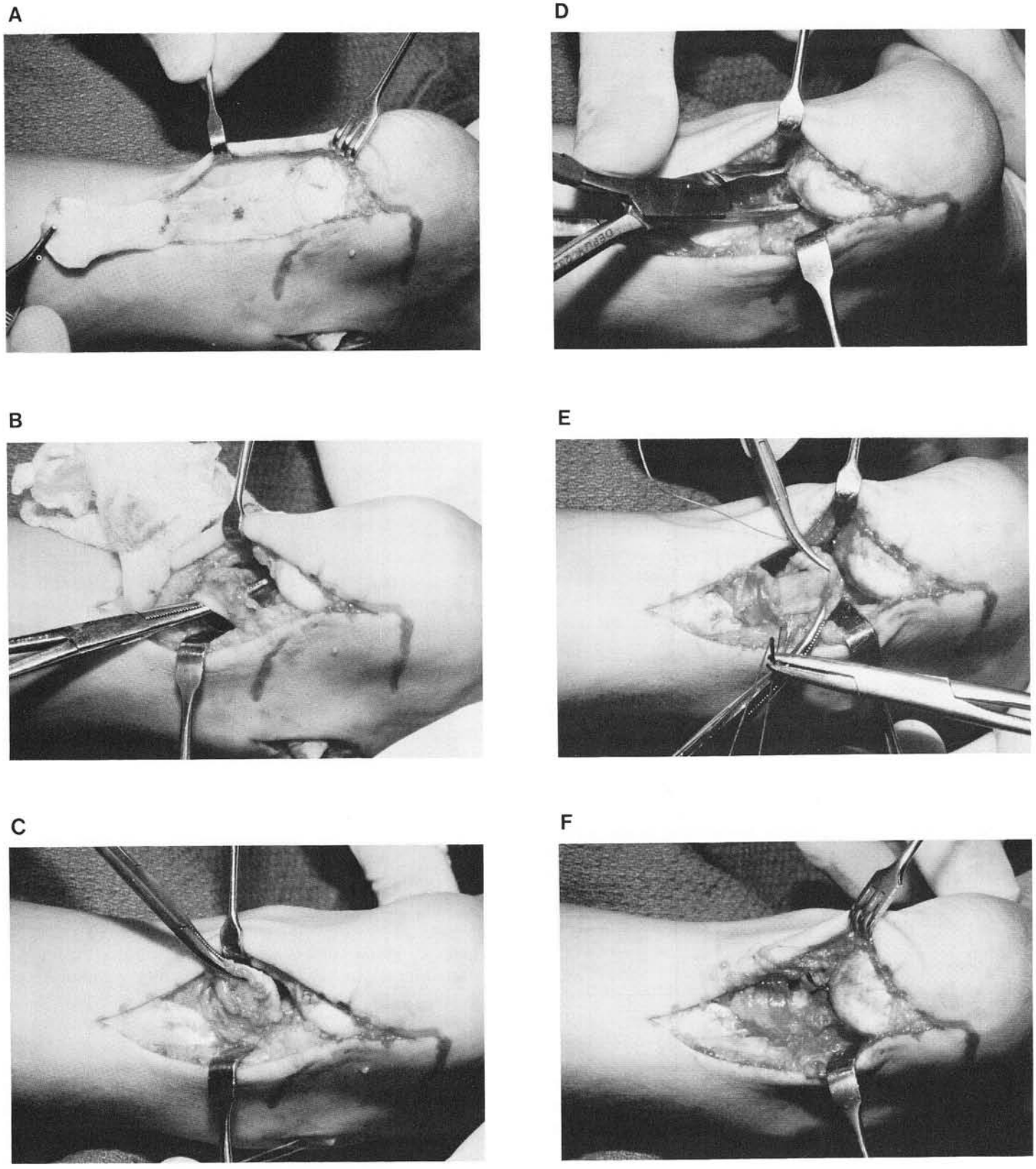

Fig. 9. A-F. Surgical demonstration of anterior advancement of the tendo Achillis.

The procedure begins with a five to eight centimeter incision extending over the distal insertional area of the tendo Achillis. The incision may be gently curved forward distally to allow better visualization later in the procedure when the advancement is performed. The incision is bluntly carried deep through the superficial fascia and vessels coagulated as necessary. The sural nerve and lesser saphenous vein are rarely visualized but are retracted laterally if they are encountered. The deep fascia and paratenon are then sharply incised and the distal portion of the tendo Achillis identified.

The tendo Achillis is then detached distally from its insertion into the distal one-half of the calcaneus (Fig. 9A) (1). In children, it is very important to avoid damage to the calcaneal apophysis when sectioning the tendon and throughout the surgical procedure. The distal portion of the tendon is frequently wider and should be maintained in its entirety.

Following detachment of the tendon, dissection is carried anteriorly on the dorsum of the calcaneus towards the subtalar joint. The posterior aspect of the subtalar joint and the deep transverse fascia are visualized. A small incision is made in the deep transverse fascia and the flexor hallucis longus tendon identified (Fig. 9B). Passive motion of the first MTPJ will usually confirm that the tendon has been properly located. The tendo Achillis will be passed anterior to the flexor hallucis longus (Fig. 9C). This has been reported to decrease the incidence of recurrence and has not been associated with pathological sequelae (2,5).

A notch is then made in the dorsum of the calcaneus immediately posterior to the posterior facet of the subtalar joint (Fig. 9D). The notch is made to accommodate the tendo Achillis and will serve as its new insertion. Two small drill holes are then made in the calcaneus from the apex of the notch and through the medial and lateral walls of the calcaneus. These holes will allow reinsertion of the tendo Achillis into the calcaneus without the need to risk an external anchor (Fig. 10). A trial fitting of the tendon into the notch is attempted and if needed any additional tendon length obtained.

A Bunnell-type suture is then placed into the distal portion of the tendo Achillis using a heavy-gauge nonabsorbable suture (Fig. 9E). The tendon is routed anterior to the flexor hallucis longus tendon, and anchored into the calcaneal notch by passing the suture ends through the drill holes and tying them (Fig. 9F). The deep fascia and paratenon are closed using 3-0 absorbable suture in simple interrupted or running interlocking fashion. The superficial fascia is closed with 4-0 absorbable suture in running subcutaneous fashion. The skin is closed with 5-0 or 6-0 absorbable suture in running subcuticular fashion. Steri-strips, a saline moistened gauze sponge, and a dry sterile dressing are applied. An above-knee cast is applied with the knee slightly flexed and with the foot angulated at ninety degrees to the leg.

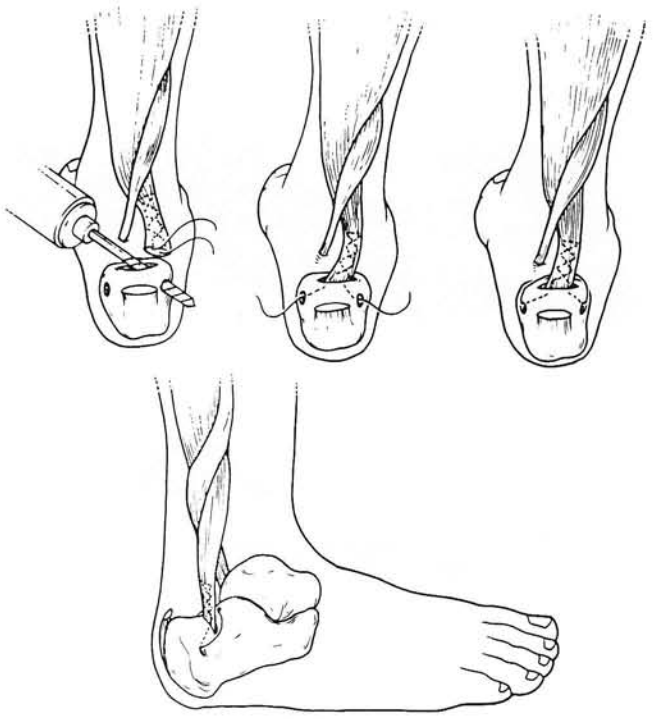

Fig. 10. Modified internal reinsertion of tendo Achillis. (Reproduced with permission from Downey MS: Ankle equinus. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Vol 1. Baltimore, Williams & Wilkins, 1987, p 393.)

The patient is kept non-weightbearing in the cast for six to eight weeks. The cast may be reduced to a below-knee cast at four to six weeks in some instances. After cast removal, exercises are begun and activity gradually increased. Occasionally, the bivalved cast shell or some other maintenance device is continued at night to decrease the chance of recurrence.

Summary

The etiologic classification of ankle equinus has been discussed with special reference to the muscular forms of ankle equinus. Selection of the appropriate surgical procedure for the correction of muscular ankle equinus is dependent upon proper identification of the etiologic type or subtype of muscular ankle equinus present. A complete history and neurological examination must be performed to determine whether spasticity is present. Current surgical procedures were described for each of the etiologic types of muscular ankle equinus. These procedures have provided consistent and predictably satisfactory results with few side effects or sequelae. Properly utilized they permit the surgeon to correct the direct and compensatory deforming influence that muscular equinus can have on the lower extremity.

References

1. Downey MS: Ankle equinus. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Vol 1. Baltimore, Williams & Wilkins, 1987, pp 368-402.
2. Downey MS, McGlamry ED: Anterior advancement of the tendo achillis. *J Am Podiatry Assoc* 77:117-122, 1987.
3. Baker LD: A rational approach to the needs of the cerebral palsy patient. *J Bone Joint Surg* 38A:313-323, 1956.
4. Fulp MJ, McGlamry ED: Gastrocnemius tendon recession: tongue in groove procedure to lengthen gastrocnemius tendon. *J Am Podiatry Assoc* 64:163-171, 1974.
5. Pierrot AH, Murphy OB: Heel cord advancement: a new approach to the spastic equinus deformity. *Orthop Clin North Am* 5:117-126, 1974.