CHAPTER 17

SURGICAL MANAGEMENT OF DROPFOOT

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Dropfoot is a deformity that involves the relationship of the foot to the leg where there is pronounced weakness or paralysis of the extensor muscles of the leg (Fig. 1). It is a deformity that is often complex, depending on the etiology, the severity of the deformity, and the presence of associated deformities. There is a high association of a dropfoot deformity with neuromuscular diseases, and often the podiatric physician will be the first to diagnose the disease.

ETIOLOGY

The etiology of a dropfoot deformity is wide ranging and often may be difficult to determine. The most common etiology is injury to the sciatic nerve or common peroneal nerve due to trauma, compression, compartment syndrome, or injections. A dropfoot is a common component found in Charcot-Marie-Tooth disease, where there is weakness of the anterior muscles of the leg. Other etiologies include residual clubfoot, cardiovascular accident, traumatic injury to the brain or spine, muscular dystrophies, spinal muscular atrophy, Guillain-Barré syndrome, cerebral palsy, spina bifida, polio, postpolio syndrome, neoplasm of the brain or spine such as astrocytoma, medulloblastoma, or neuroblastoma, or spinal dysraphism such as lipoma, tethered cords, syringomyelia, or diastematomyelia. Each disease associated with a dropfoot has its own distinct qualities and should be taken into consideration when addressing the deformity. The etiology of dropfoot may be unknown in some presentations and is thought to be a subclinical form of a neuromuscular disease.

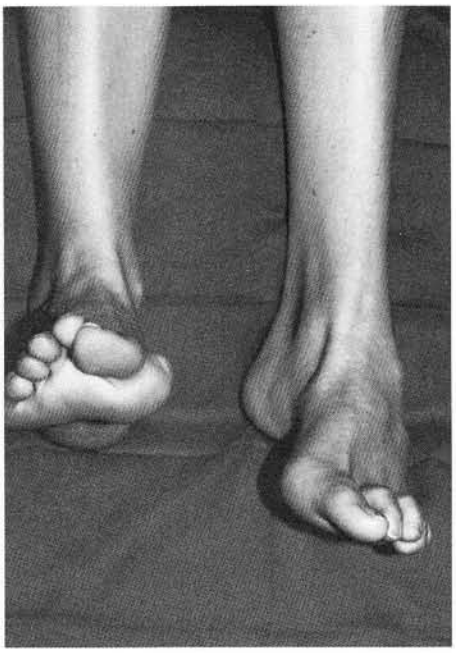

Figure 1. A dropfoot deformity seen in a patient with Charcot-Marie-Tooth disease.

EVALUATION

A dropfoot is often a component of a complex deformity with many variables to consider. The most essential part of the evaluation is an accurate history and physical examination. The clinician should be suspicious of a neuromuscular disease in a previously undiagnosed patient. The neurological portion of the examination combined with the history gives the physician a good understanding of the type of disorder the patient may have, as well as the probable course of the disease. The lower extremity physical exam should concentrate on areas of sensory deficits, abnormal reflexes, and muscle weaknesses. It is important to determine the strength of the muscles of the leg of both extremities. This information will give the physician the normal and abnormal muscle strength for each muscle for that patient. Muscles are graded on a scale of zero to five, with five being normal muscle strength and zero being absence of muscle contraction (Table 1). The strength of each muscle must be determined before an effective treatment plan can be considered. An equally important part of the physical examination is a gait analysis to determine how the patient functions with the deformity.

In addition to the history and physical examination, there are studies that can aid in the diagnosis and treatment of a dropfoot deformity. These studies include electromyography, nerve

Table 1

MUSCLE GRADING

	GRADE	DESCRIPTION
5	Normal	Full Resistance
4	Good	Partial Resistance
3	Fair	Movement against Gravity
2	Poor	Movement with Gravity Eliminated
1	Trace	Visual Muscle Contraction
0	None	No Contraction

conduction velocities, x-rays, computed tomography, or magnetic resonance imaging. If you are the first physician to identify the diagnosis of a neuromuscular disease, you should ascertain a neurological consult before proceeding with the surgical plan.

Once the etiology of the deformity has been determined, a better understanding of the nature of the disease course has been gained. At this point the state of the progression of the deformity must be determined. If the deformity is fully reducible, then the patient will function well with bracing or tendon transfers. The patient with a deformity that is rigid and not reducible will require an arthrodesing procedure. Spastic deformities require chemical injections to weaken the muscle, serial lengthenings, or tendon transfers and are beyond the scope of this article.[1,2] Once the etiology of the deformity, the stage of the disease, and the type of deformity have been determined, the appropriate treatment plan can be formulated.

TREATMENT

The treatment options are directly dependent on the severity of deformity and whether it is progressive or static. Conservative therapy is utilized in the flexible deformity or in the nonsurgical patient. An ankle-foot orthosis helps to maintain the proper position of the deformity to allow for maximal funtion of the extremity (Fig. 2). Younger patients often become dissatisfied with the appearance of the brace and find it cumbersome. At this point patients often elect to proceed with surgery.

Surgical intervention is considered in those patients where bracing fails, or the deformity is more severe. In the patient with a flexible deformity, a tendon transfer is commonly employed of the tibialis anterior, peroneus longus, or tibialis posterior tendons. A tendon transfer may be combined with an osseous procedure in the patient with a semi-rigid type of deformity for the best stabilization. However, the rigid deformity will require an arthrodesing procedure to maintain a permanent position.

Tendon transfers are indicated in flexible and semi-rigid deformities, where the deformity can be fully or partially reduced. The purpose of a tendon transfer is to improve motor function, eliminate deforming forces, attempt to eliminate spasticity, improve stability, eliminate the need for bracing, and improve cosmesis. When performing tendon transfers, certain principles should be adhered to as outlined by many sources.[3-7] One must determine if the muscle to be transferred has sufficient strength to provide the necessary function, because the muscle may lose one grade strength when transferred.[6,8] It would not be practical to transfer a muscle with less than a grade four strength, because the benefits would not be as rewarding. Along with considering the strength of a muscle, the adaptability should be determined. Muscles should be chosen that are functionally similar (stabilizers versus accelerators), or within the same phase of gait, stance or swing. Re-education of the transferred tendon can be undertaken preoperatively and postoperatively for the out of phase transfers to provide the best possible function.

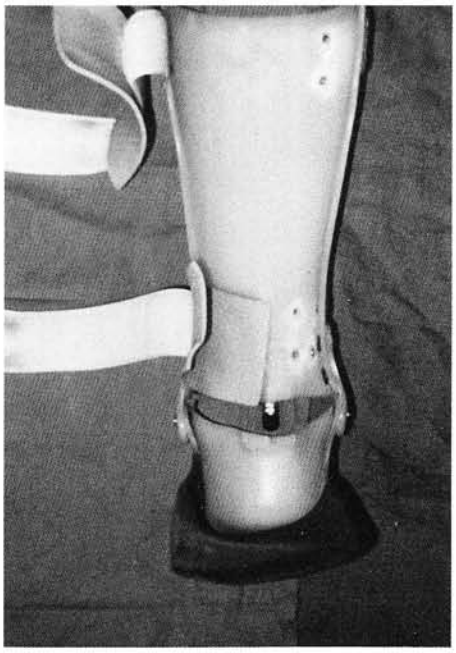

Figure 2. An example of an ankle-foot orthosis.

There are many techniques for reinsertion of the transferred tendon into bone or tendon. The most appropriate technique is to anastomose the transferred tendon to the tendon with which you are functionally trying to replace in deformities that have no varus or valgus components. Typically, a nonabsorbable suture such as an 0 or 2-0 Ethibond® or Mersilene® is utilized when anastomosing tendons. If the tendon you are trying to anastomose with is not present or you are transferring to another location to correct for a varus or valgus position, then an osseous insertion is preferred. The technique of osseous insertion is performed with bone anchors, such as the Mitek anchor (Mitek, Inc., Westwood, MA) or other techniques that have their own unique properties.[8]

Tibialis Anterior Tendon Transfer

The tibialis anterior tendon transfer is indicated in a deformity that is reducible and does not have an osseous component. The tibialis anterior tendon transfer can help to reduce the supinatory force and aid in dorsiflexion at the ankle. The tendon transfer is a three incisional technique as described by McGlamry.[9-11] The first incision is made over the insertion of the tibialis anterior tendon where the tendon is isolated (Fig. 3). Attention is then directed to the junction of the distal and middle one-third of the leg over the tibialis anterior tendon. This incision is important to allow for passage of the tendon within the appropriate tendon sheath. A third incision is made over the peroneus tertius tendon near its insertion at the fifth metatarsal base. The tibialis anterior tendon is transected and passed within its tendon sheath with a tendon passer to the incision at the proximal portion of the leg. The tendon passer is then inserted at the level of the peroneus tertius incision, and retrograded to the proximal incision. The tibialis anterior tendon is tagged with suture to facilitate transfer, and the tendon is brought to the insertion site. The foot is placed in the proper position in relation to the leg and the tibialis anterior tendon is anastomosed to the peroneus tertius tendon with an 0 or 2-0 Ethibond® or Mersilene® suture. The patient is then placed in a below-knee, non-weight-bearing cast for six weeks. The patient will begin passive range of motion at the fifth to sixth week, partial-weight bearing at the sixth to seventh week, and full-weight bearing at the seventh week.

Peroneus Longus Tendon Transfer

The peroneus longus tendon transfer is the most common one performed, because it is easy to perform and readily adapts to its new function. A three or four incisional approach is utilized as described by McGlamry.[12] The first incision is placed at the lateral aspect of the cuboid where the peroneus longus tendon is isolated as it passes from lateral to medial across the plantar aspect of the foot (Fig. 4). A second incision is placed at the lateral aspect of the junction of the distal and middle one third of the leg, where the peroneus longus tendon is superficial to the peroneus brevis. The third incision is placed over the tibialis anterior tendon at its insertion. The fourth incision is optional, and can be performed at the level of the insertion of the peroneus tertius tendon or the first incision can be extended distally.

The peroneus longus tendon is then transected, and the remaining distal portion is sutured

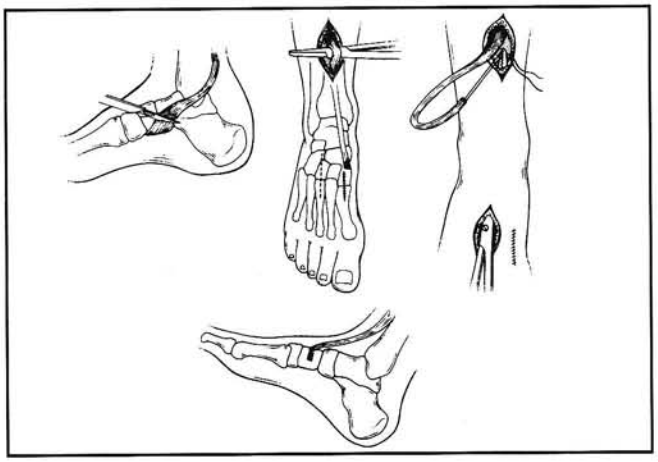

Figure 3. Technique for the tibialis anterior tendon transfer.

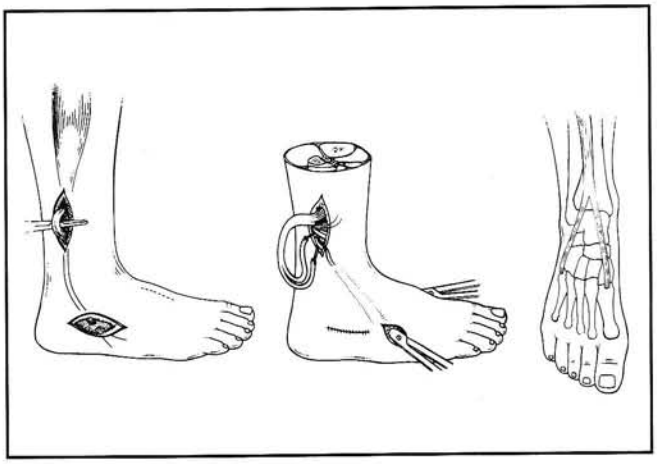

Figure 4. The technique for transferring the peroneus longus tendon.

to the peroneus brevis tendon. The peroneus longus is then passed within its tendon sheath to the incision at the proximal and lateral aspect of the leg. The tendon is then split with umbilical tape for transfer into the tibialis anterior and peroneus tertius tendons, if there is not a varus or valgus deformity. The tendon passer is then retrograded from the distal incisions over the tibialis anterior and peroneus tertius tendons to the proximal incision. The split peroneus longus tendons are then passed distally. The foot is appropriately positioned in relation to the leg, and the tendons are anastomosed with an 0 or 2-0 Ethibond® or Mersilene® suture. The patient is then placed in a below-knee, non-weight-bearing cast for six weeks. The patient can begin passive range of motion at the fifth to sixth week, partial-weight bearing at the sixth to seventh week, and full-weight bearing at the seventh week.

Tibialis Posterior Tendon Transfer

The tibialis posterior tendon transfer is indicated when the dropfoot deformity is moderate to severe, though remains flexible. The tibialis posterior transfer is a more complex procedure and is often not utilized, though results are very satisfying. A five incisional approach is more commonly used for the split tibialis posterior transfer, or a four incision approach when one insertion is utilized.[12-14] The first incision is placed over the insertion of the tibialis posterior tendon, where the tendon is isolated (Fig. 5). A second incision is made at the posterior medial junction of the distal and middle one-third of the leg, where dissection is carried down to the myotendinous junction of the tibialis posterior. One must be careful not to damage the neurovascular bundle, which is posterior to the tibialis posterior muscle. The third incision is placed lateral to the tibial crest at the junction of the distal and middle one-third of the leg. The tibialis anterior muscle is identified and separated from the lateral aspect of the tibia. The anterior neurovascular bundle is carefully retracted laterally exposing the interosseous membrane (Fig. 6). The tibialis posterior tendon is then transected at its insertion and passed to the posterior medial incision. The interosseous membrane is then windowed anteriorly, to allow a small portion of the tibialis posterior muscle belly to pass through the membrane.

If there is a varus or valgus position of the foot, the tendon is transferred into the first, second, or third cuneiform or the cuboid. If a varus or valgus position is not present, then the preferred technique is to split the tibialis posterior tendon. Incisions are then made over the insertions of the tibialis anterior and peroneus tertius tendons. The split tibialis posterior tendon is then passed distally down the tendon sheaths and anastomosed to the tibialis anterior and peroneus tertius tendons with an 0 or 2-0 nonabsorbable suture at the appropriate physiologic tension. One must be careful when the tibialis posterior is not split, because the muscle is a very powerful one and can easily lead to an excessive valgus or varus position.[15] The transferred tibialis posterior tendon does not as readily adapt as the transferred peroneus longus tendon, but the transferred tendon can be re-educated with the proper physical therapy preoperatively and postoperatively. The

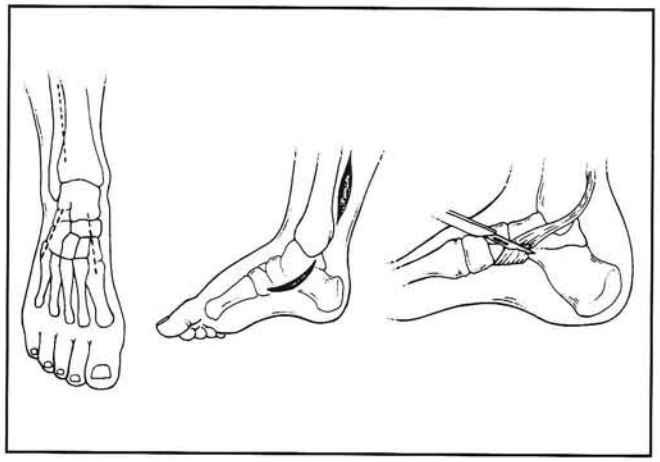

Figure 5. The incision placements for the tibialis posterior tendon transfer.

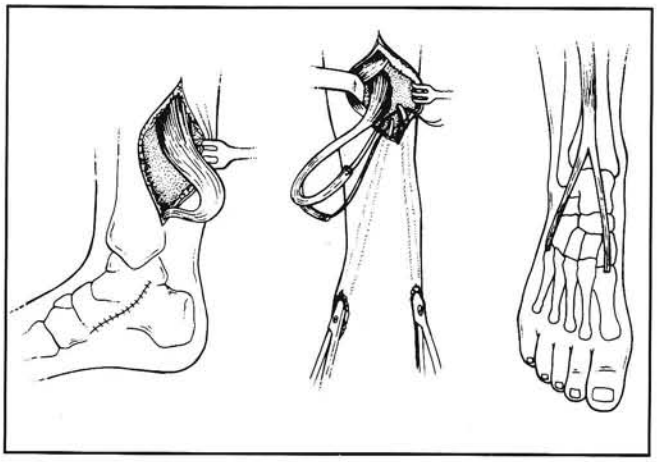

Figure 6. The technique for transferring the tibialis posterior tendon.

patient is then placed in a below-knee, non-weight-bearing cast for six weeks. The patient will begin passive range of motion at the fifth to sixth week, partial-weight bearing at the sixth to seventh week, and full-weight bearing at the seventh week.

Tendon Transfer & Osseous Procedure

In a deformity that is semi-rigid and only partially reducible, a tendon transfer can be combined with an osseous procedure, such as a talonavicular arthrodesis or triple arthrodesis for a more effective correction. The arthrodesing techniques are discussed in detail in other texts.[16,17] The most effective tendon transfers are the peroneus longus and tibialis posterior, when combined with a talonavicular or triple arthrodesis. The arthrodesis will provide a more rigid lever for the tendon transfer to function maximally. The patient will then remain non-weight bearing for 8 to 12 weeks because of the arthrodesis.

Arthrodesing Procedure

A deformity that is not reducible, rigid, and has structural changes necessitates an osseous procedure to provide the best position of the foot to the leg. An ankle or pantalar arthrodesis maintains the proper alignment of the foot to the leg. A pantalar arthrodesis is routinely staged to avoid avascular necrosis of the talus. An ankle arthrodesis is performed in the standard fashion with internal or external fixation, which is described in greater detail in other texts.[17-19] Arthrodesis of the ankle provides permanent correction of the dropfoot deformity.

SUMMARY

It is important to understand the etiology of the dropfoot in order to appropriately treat the deformity. The podiatric physician is often the first to make the diagnosis of a neuromuscular disease, and the patient should have a neurological consultation before proceeding with surgery. The severity of the deformity must be determined in order to proceed with the most appropriate treatment plan. The patient and surgeon should determine the goals of the surgery, whether to improve function, to improve stability, to reduce pain, to eliminate the need for bracing, or to improve cosmesis. For the flexible deformity, an early tendon transfer can provide function for many years before a more final osseous procedure is performed. The technique of tendon splitting allows for a more balanced suspension with a better functional result. The rigid deformity necessitates an ankle or pantalar arthrodesis for permanent correction of the dropfoot. The dropfoot deformity is often a part of a more complex deformity due to the disease state, and all the components should be considered thoroughly prior to determining the course of treatment.

REFERENCES

1. Miller SJ: Pediatric spastic equinus deformity. In Camasta CA, Vickers NS, Ruch JA, eds. *Reconstructive Surgery of the Foot and Leg, Update '94*. Tucker, GA; Podiatry Institute Publishing; 1994: 21-26.
2. Waters RL, Garland DE: Disorders of the Lower Extremity in the Stroke and Head Trauma Patient. In Jahss MH, ed. *Disorders of the Foot and Ankle*, 2nd ed, Philadelphia, Pa; W.B. Saunders Company; 1991:2080-2088.
3. Mayer L: The physiological method of tendon transplantation. I. historical; anatomy and physiology of tendons. *Surg Gynecol Obstet* 22:182-197, 1916.
4. Mayer L: The physiological method of tendon transplantation. Ii. Operative technique. *Surg Gynecol Obstet* 22:298-306, 1916.
5. Mayer L: The physiological method of tendon transplantation. Iii. Experimental and clinical experiences. *Surg Gynecol Obstet* 22:472-481, 1916.
6. Green WT, Grice DS: The Surgical Correction of the Paralytic Foot. *Instr Course Lect* 10:343-363, 1953.
7. Mayer L: The physiological method of tendon transplantation in the treatment of paralytic drop-foot. *J Bone Joint Surg* 19:389-394, 1937.
8. Miller SJ: Principles of Muscle-Tendon Surgery and Tendon Transfers. In McGlamry ED, Banks AS, Downey MS, eds. *Comprehensive Textbook of Foot Surgery* 2nd ed, Baltimore, Md; Williams and Williams; 1992:1297-1333.
9. McGlamry ED: Transfer of the tibialis anterior tendon. *J Am Podiatry Assoc* 63:609-617, 1973.
10. McGlamry ED, Kitting RW: Equnius foot; an analysis, of the etiology, pathology, and treatment techniques. *J Am Podiatry Assoc* 63:165-184, 1973.
11. McGlamry ED, Ruch JA, Green DR: Simplified technique for split tibialis anterior tendon transposition. *J Am Podiatry Assoc* 65:927-937, 1975.
12. McGlamry ED, Butlin WE, Ruch JA: Treatment of forefoot equinus by tendon transpositions. *J Am Podiatry Assoc* 65:872-888, 1975.
13. Gunn DR, Molesworth BD: The use of the tibialis posterior as a dorsiflexor. *J Bone Joint Surg* 39B:674-678.
14. Hsu JD, Hoffer MM: Posterior tibial tendon transfer anteriorly through the interosseous membrane. A modification of the technique. *Clin Orthop* 131:202-204, 1978.
15. Fenton CF, Gilman RD, Jassen M, Dollard M, Smith GA: Criteria for selected major tendon transfers in podiatric surgery. *J Am Podiatry Assoc* 73:561-568, 1983.
16. Dinapoli DR, Ruch JA: Triple arthrodesis and subtalar joint fusions. In McGlamry ED, Banks AS, Downey MS, eds *Comprehensive Textbook of Foot Surgery* 2nd ed, Baltimore, MD; Williams and Williams; 1992:1040-1075.
17. LaBianco GJ, Vito GR, Kalish SR: Use of the Ilizarov external fixator in the treatment of lower extremity deformities. *J Am Podiatric Med Assoc* 86:523-531, 1996.

18. Mahan KT: Ankle and Pantalar Fusion. In McGlamry ED, Banks AS, Downey MS, eds: *Comprehensive Textbook of Foot Surgery* 2nd ed, Baltimore, MD: Williams and Williams; 1992:1076-1091.
19. Mahan KT, Yu GV, Kalish SR, Corey SV: Podiatry Institute ankle fusion technique. *J Am Podiatric Med Assoc* 87:101-116, 1997.

ADDITIONAL REFERENCES

Banks AS: Idiopathic and neurological cavus foot deformities the role of tendon transfers. In McGlamry ED, ed. *Reconstructive Surgery of the Foot and Leg, Update 88*. Tucker, Ga; Podiatry Institute Publishing; 1988:22-29.

Bouchard JL, Castellano BD: Dropfoot-Tendon Surgery. In McGlamry, ED, ed. *Reconstructive Surgery of the Foot and Leg, Update 88*. Tucker, Ga; Podiatry Institute Publishing; 1988:30-35.

Fenton CF, Schlefman BS, McGlamry ED: Surgical considerations in the presence of Charcot-Marie-Tooth disease. *J Am Podiatry Assoc* 74: 490-498.

Izzo KL, Aravabhumi S: Cerebrovascular accidents. *Clin Podiat Med Surg* 6:4: 745-759, 1989.

LaBianco GJ: The use of electromyographic and nerve conduction studies. In Vickers NS, ed. *Reconstructive Surgery of the Foot and Leg, Update 96* Tucker, Ga;: Podiatry Institute Publishing; 1996: 291-292.