IDIOPATHIC AND NEUROLOGIC CAVUS FOOT DEFORMITIES THE ROLE OF TENDON TRANSFERS

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The association of the cavus foot deformity with neurologic disease has been well documented by Brewerton and associates (1). Of the first 77 patients presenting to the pes cavus clinic 66% were found to have a neurologic disorder after clinical examination alone. Another seven patients had abnormal electrodiagnostic tests. The remainder were classified as "idiopathic" in nature. The idiopathic cavus foot may represent a form fruste, or subclinical presentation of an underlying neurologic disorder in which the foot deformity is the only remarkable finding.

Given the fact that many cavus feet will be associated with neurologic problems, how does one decide which if any surgical procedures are to be performed? Furthermore, how does one justify the use of tendon transfer in the face of neurologic disease?

The first question should be directed toward the disease itself, not simply the foot. Surprisingly many patients have undiagnosed neurologic disease until seen by a podiatrist. As many of the causes of the cavus foot can be readily ascertained by clinical examination, the podiatrist is in a position to play an important role in diagnosing a specific disease entity. Much will be determined by the absence or presence of neurologic disease and the nature of its progression.

Questioning should be aimed at determining the age of onset of the foot deformity as well as its rate of progression. A very early childhood onset with a rapid progression should encourage the physician to look for a more serious neurologic disorder.

Should only one foot be affected, then the likelihood of proximal etiologies is greatly increased. A later onset with bilateral involvement and a more even sustained course of progression may also indicate neurologic disease, but of a lesser magnitude or a lesser disease entity. A family history of cavus foot deformity may also assist one in making a prospective diagnosis.

As mentioned earlier, 66% of Brewerton's patients were diagnosed as having neurologic disease based upon clinical examination alone (1). A valuable yet simple method of examination is manual muscle testing. In addition to searching for evidence of muscle weakness, attempts should be made to correlate any muscle deficits with patterns or specific muscle groups. For example, a patient with a drop foot may present with weakness of the anterior leg compartment alone or in combination with weakness of the peroneus brevis and/or the foot intrinsic muscles. Isolated anterior compartment deficits may lead one to suspect a more proximal lesion, perhaps involving spinal level L-4. If other muscles are involved, then one may tend to suspect a more generalized process. Isolated weakness should also stir the clinician to search for weakness in the hip or thigh as well as any sensory deficits. In addition to strength, one should evaluate the tone and quality of the muscle function to rule out evidence of clonus or spasticity.

Further neurologic examination involving the evaluation of ankle and patella reflexes, plantar response, as well as other tests will be helpful in ruling out specific disease entities (Fig 1).

When considering surgery on the cavus foot several factors must be weighed.

Whether or not to arthrodese. Arthrodesis has become a primary procedure in many cavus feet for several reasons. Joint fusion allows for permanent correction of deformity and maintenance of the desired position. The newly created alignment should improve function and in some instances the effects of muscle imbalance may be neutralized. Theoretically the effectiveness of weakened muscles should be enhanced as the tendon has fewer joints to stabilize. Evidence of a progressive disorder such as Charcot-Marie-Tooth disease will more than likely lead one to perform arthrodesis, whereas an idiopathic cavus foot may respond adequately to other reconstructive measures depending upon the degree of deformity and the flexibility of the structures. Adequate stability of the involved joints will be required regardless of the cause of the cavus foot. Consequently, arthrodesis may be required in the idiopathic pes cavus as well.

Whether or not to transfer a tendon. Several factors must be weighed. What is the purpose of the proposed transfer? A procedure of this type may be used to recreate function in an area where there is a deficiency or else to relieve the deforming effects of a specific muscle. In a patient with Charcot-Marie-Tooth disease a dropfoot may be temporarily assisted with a peroneus longus transfer to the dorsum of the foot. This will also aid in relieving the muscle's profound plantarflexory force at the first ray which tends to perpetuate the cavus deformity.

Muscle strength needs to be carefully assessed as one grade of power may be lost following tendon transfer. This is not because transfer inherently results in muscle weakness, but more likely because it is impossible to recreate the specific vectors of force and the natural mechanical advantages a muscle/tendon unit possesses for its original function. Also the contractile ability of the muscle will not be as ideally suited for the new function as it was for the original.

Adequate range of motion is required if the tendon is to perform its new function satisfactorily. If an ankle equinus is present then transfer of a tibialis posterior tendon to the dorsum of the foot may have a limited effectiveness. This is due to an inherent shortage of motion available as well as the fatigue the muscle will undergo as constant resistance to dorsiflexion is met with each contraction.

Stability of the surrounding joints will be required. In some patients this may only require orthotic support, while in others arthrodesis may be necessary. Instability may result in a new deformity being caused by the transferred tendon.

Split Tibialis Anterior Tendon Transfer (STATT)

This is technically one of the easiest tendon transfers to perform. This procedure may be better understood by examining the relationship of the tibialis anterior and the subtalar joint axis. In the average foot the tendon of the tibialis anterior lies just medial to the subtalar joint axis making it a mild invertor of the foot upon dorsiflexion. However, in the pes cavus the adducted forefoot shifts the insertion of the tendon somewhat more medialward, and accentuates the inversion and adductory capabilities of the muscle. Likewise, in the pronated foot the tendon will lie lateral to the subtalar joint axis and hence become an evertor of the foot. The tibialis anterior is also a strong supinator about the oblique midtarsal joint axis. In the cavus foot if half of the tendon is transferred to a more lateral position then the net result is a more rectus dorsiflexory force at the ankle. The function and phase of the tendon is essentially the same as its original position. Consequently as the vector of contraction has been redirected more perpendicular to the ankle joint axis the effective dorsiflexory strength of the tibialis anterior has been increased. Therefore, very little muscle strength is lost following STATT in comparison to other tendon procedures. The effectiveness of the procedure has previously been reviewed by McGlamry and Bouchard (2).

As the tibialis anterior is usually affected quite early in Charcot-Marie-Tooth disease transfer is not recommended in this situation. This procedure tends to work best as an adjunctive procedure in elective reconstruction of the idiopathic cavus foot. Theoretically the transfer will reduce the dorsiflexory power at the first metatarsal and perhaps accentuate the plantarflexory capabilities of the peroneus longus. Consequently, either a peroneal halt or a dorsiflexory first metatarsal osteotomy may be performed in conjunction. In the more flexible cavus foot types the STATT will reduce the degree of inversion at heel strike and potentially assist in relieving a certain degree of rearfoot instability.

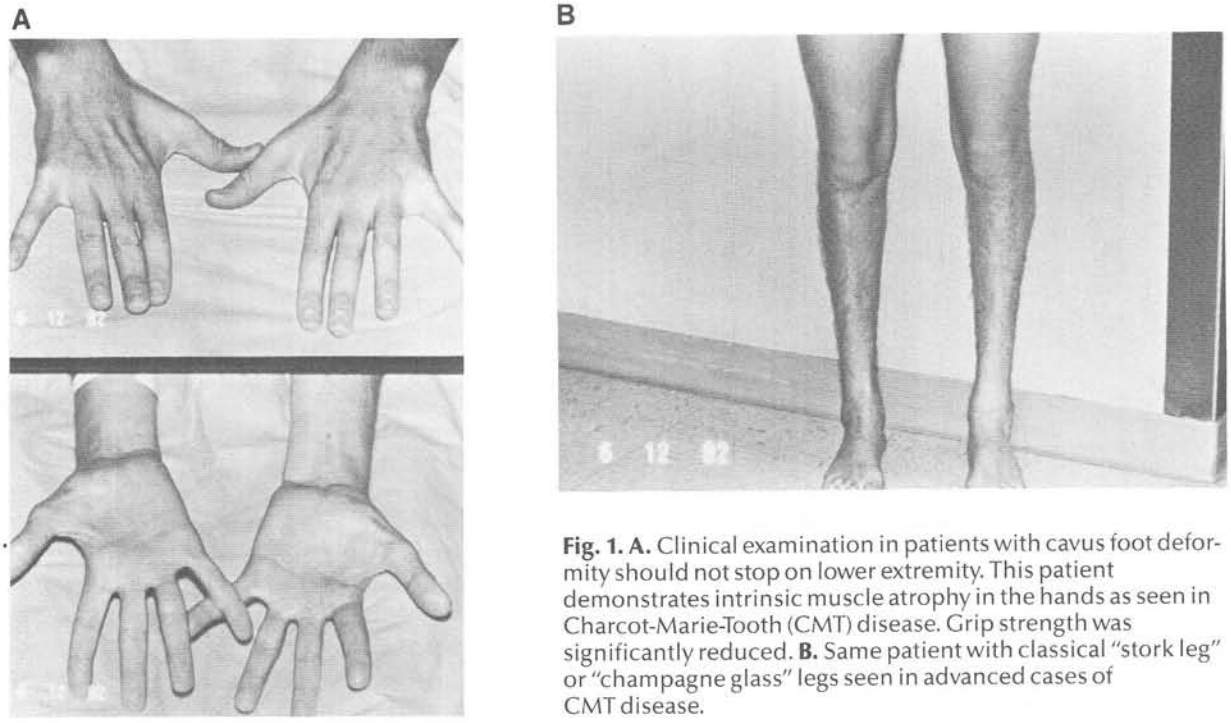

Fig. 1. A. Clinical examination in patients with cavus foot deformity should not stop on lower extremity. This patient demonstrates intrinsic muscle atrophy in the hands as seen in Charcot-Marie-Tooth (CMT) disease. Grip strength was significantly reduced. **B.** Same patient with classical "stork leg" or "champagne glass" legs seen in advanced cases of CMT disease.

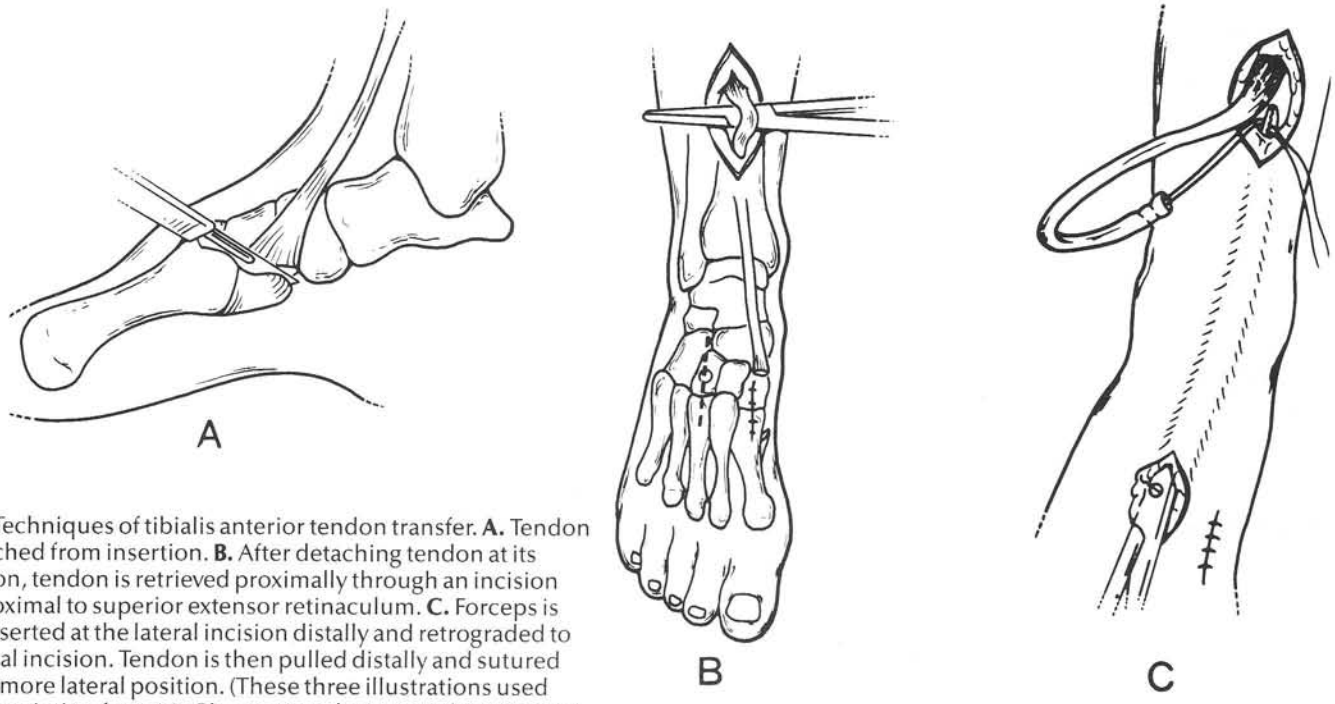

Fig. 2. Techniques of tibialis anterior tendon transfer. **A.** Tendon is detached from insertion. **B.** After detaching tendon at its insertion, tendon is retrieved proximally through an incision just proximal to superior extensor retinaculum. **C.** Forceps is then inserted at the lateral incision distally and retrograded to proximal incision. Tendon is then pulled distally and sutured into its more lateral position. (These three illustrations used with permission from McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Williams & Wilkins, 1987.)

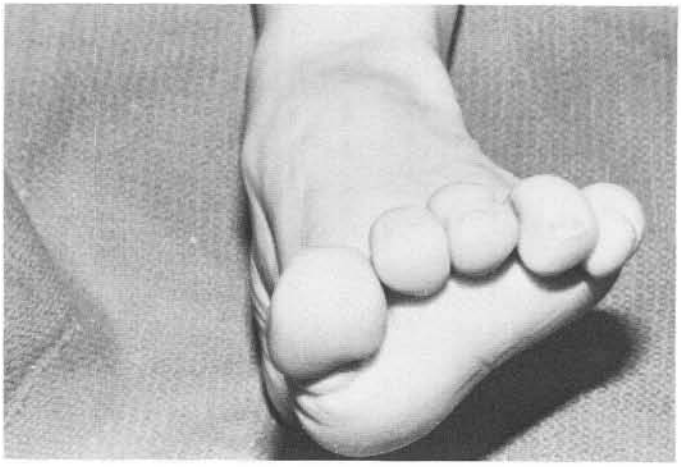

Fig. 3. Patient 20 years post tibialis anterior tendon transfer utilized to treat residual clubfoot deformity. Note that foot is extremely everted in the dorsiflexed position. With peroneus longus unopposed first ray has assumed symptomatic plantar position. Since tendon in this case was transferred subcutaneously the "bowstring" effect is noted at dorsolateral ankle.

The specific surgical technique has been described by McGlamry and associates (3).

Another option is to transfer the entire tibialis anterior tendon and insert it into the third cuneiform or metatarsal. This produces a much more profound evertor force. However, small degrees of lateral displacement beyond the midline may have a profound pronatory effect on the foot (4). Generally speaking the split transfer is preferred (Figs. 2-4).

Peroneus Longus Tendon Transfer

Once again, a relatively easy procedure to perform technically. This procedure is most commonly employed in cases of anterior compartment weakness with resultant dropfoot (Fig. 5). The peroneus longus is a strong muscle with a similar phasic activity to the anterior musculature and therefore, should be fairly easy to retrain postoperatively. Although Charcot-Marie-Tooth disease is commonly known as peroneal muscular atrophy, our experience has shown that the peroneus longus is rarely affected until very late in the disease process. This terminology probably reflects the fact that precise muscle evaluation techniques were not employed by early examiners. Clinical correlation is usually evident as a severe plantarflexed first ray is a common finding in the majority of these patients. Early weakness of the peroneus longus would result in elevation or hypermobility of the first ray. Utilizing the peroneus longus to assist in dorsiflexion may carry the added benefit of ne-

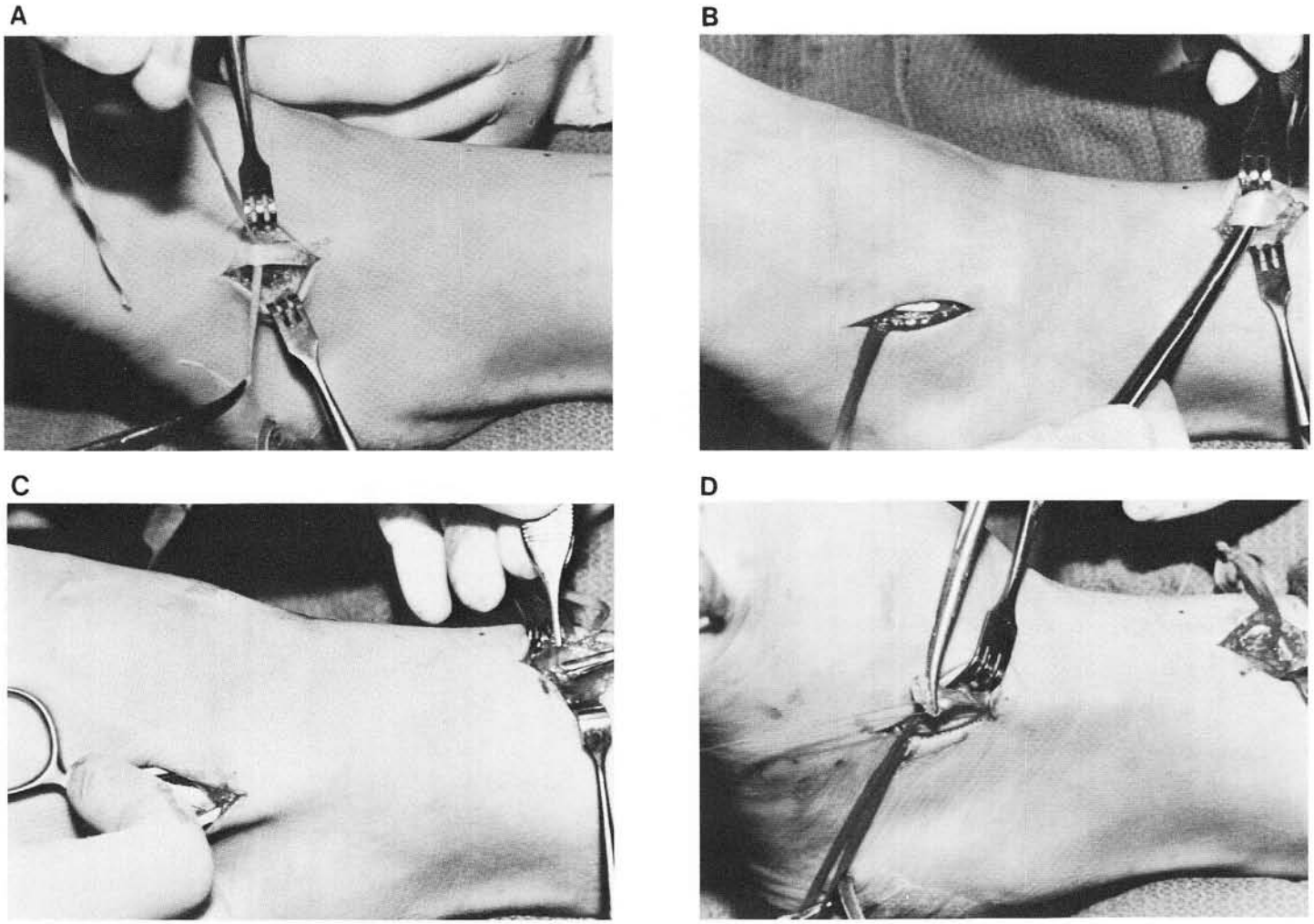

Fig. 4. Split tibialis anterior tendon transfer is preferred as opposed to transferring entire tendon. **A.** Peroneus tertius tendon is isolated. **B.** Proximal incision and identification of tibialis anterior above ankle. **C.** After detaching one-half of tendon from its insertion, this free half is retracted proximally. A forceps is then introduced retrograde to pull the tendon slip distally and laterally to its new position. **D.** Lateral half of tibialis anterior is then sutured into peroneus tertius.

gating the need for a dorsiflexory first metatarsal osteotomy in some instances (Fig. 6).

On the negative side the peroneus longus will probably not hold up as long as a tibialis posterior tendon transfer in CMT disease as the latter is usually stronger and one of the last muscles affected. Another potential drawback is the relatively short contractile path which the peroneus longus normally employs. This may mean that although adequate dorsiflexory power is available, the exclusion of motion is not optimum.

Tibialis Posterior Tendon Transfer

The tibialis posterior tendon transfer is perhaps the most common tendon transfer employed at Doctors Hospital in the treatment of the pes cavus foot. In the CMT patient the tibialis posterior is usually one of the last muscles to undergo degeneration. It is quite a strong unit with a fair excursion of motion. Consequently, post-transfer dorsiflexory strength may be good, but the range voluntary motion may be limited. Loss of the tibialis posterior function has been known to lead to pes valgus deformity, however, the transfer is usually combined with a triple arthrodesis which eliminates such concern. The technique of choice is transferring the tendon anteriorly through the interosseous membrane (Fig. 7).

The procedure is rarely performed in the idiopathic cavus foot as sufficient dorsiflexory power is usually available. It may be used in cases of dropfoot secondary to traumatic or other etiologies where the posterior compartment has been spared at the expense of the anterior leg muscles. Continuous support with orthotic devices postoperatively may be required to prevent the formation of a symptomatic flatfoot deformity. As a rule of thumb the tibialis posterior tendon should not be transferred without a talonavicular or triple arthrodesis except in instances where the calcaneus

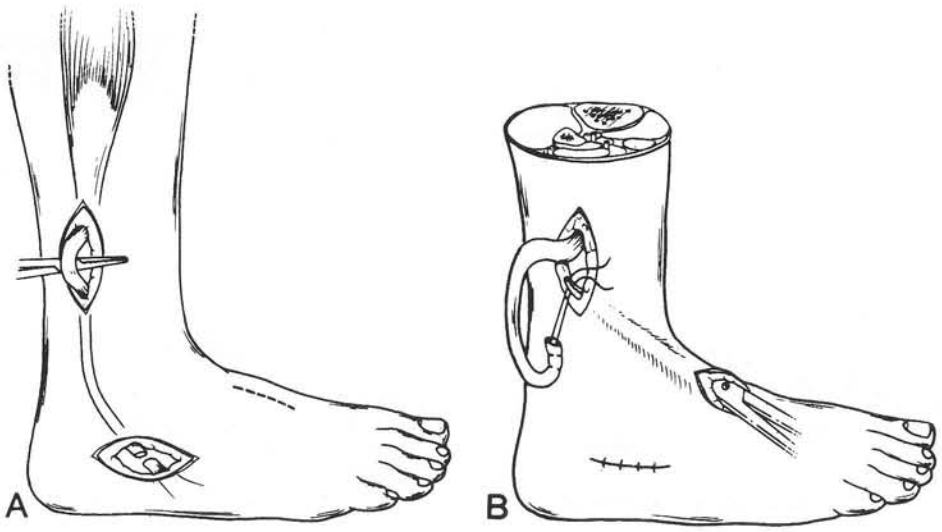

Fig. 5. Transfer of peroneus longus. **A.** Tendon is detached distally as it reaches lateral aspect of cuboid. It is then retracted through proximal incision. **B.** Peroneus longus is then passed through lateral intermuscular septum and extensor compartment. Tendon is usually split with half being sutured into tibialis anterior and half into peroneus tertius. (Used with permission from McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Williams & Wilkins, 1987.)

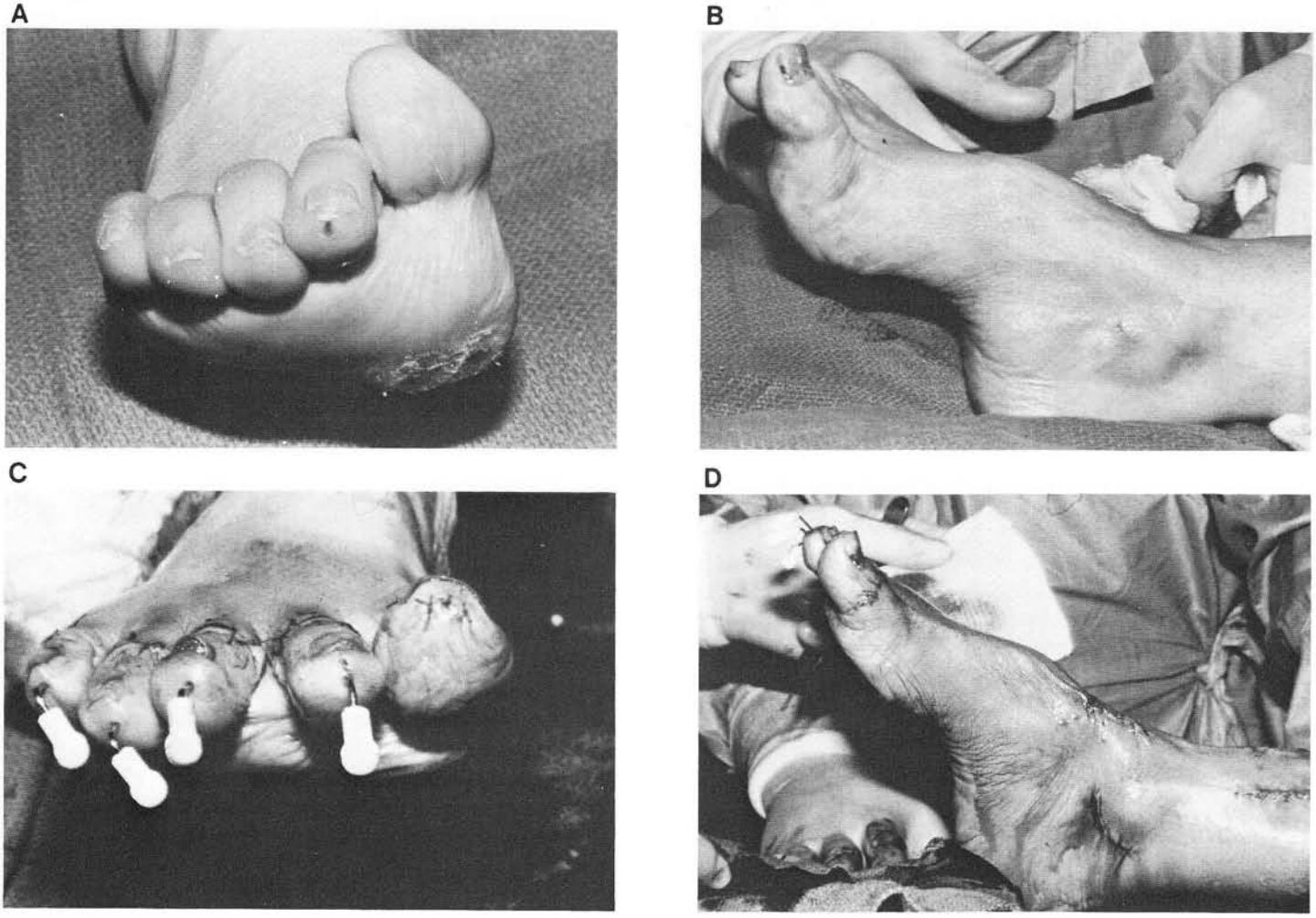

Fig. 6. Patient with cavus foot deformity following polio with paralysis of tibialis anterior. **A. & B.** Note plantarflexed attitude of first ray prior to surgery. **C. & D.** Appearance of first ray following hallux interphalangeal joint fusion and peroneus longus transfer. Dorsiflexory metatarsal osteotomy was not performed. Flexor digitorum longus tendon was also transferred dorsally.

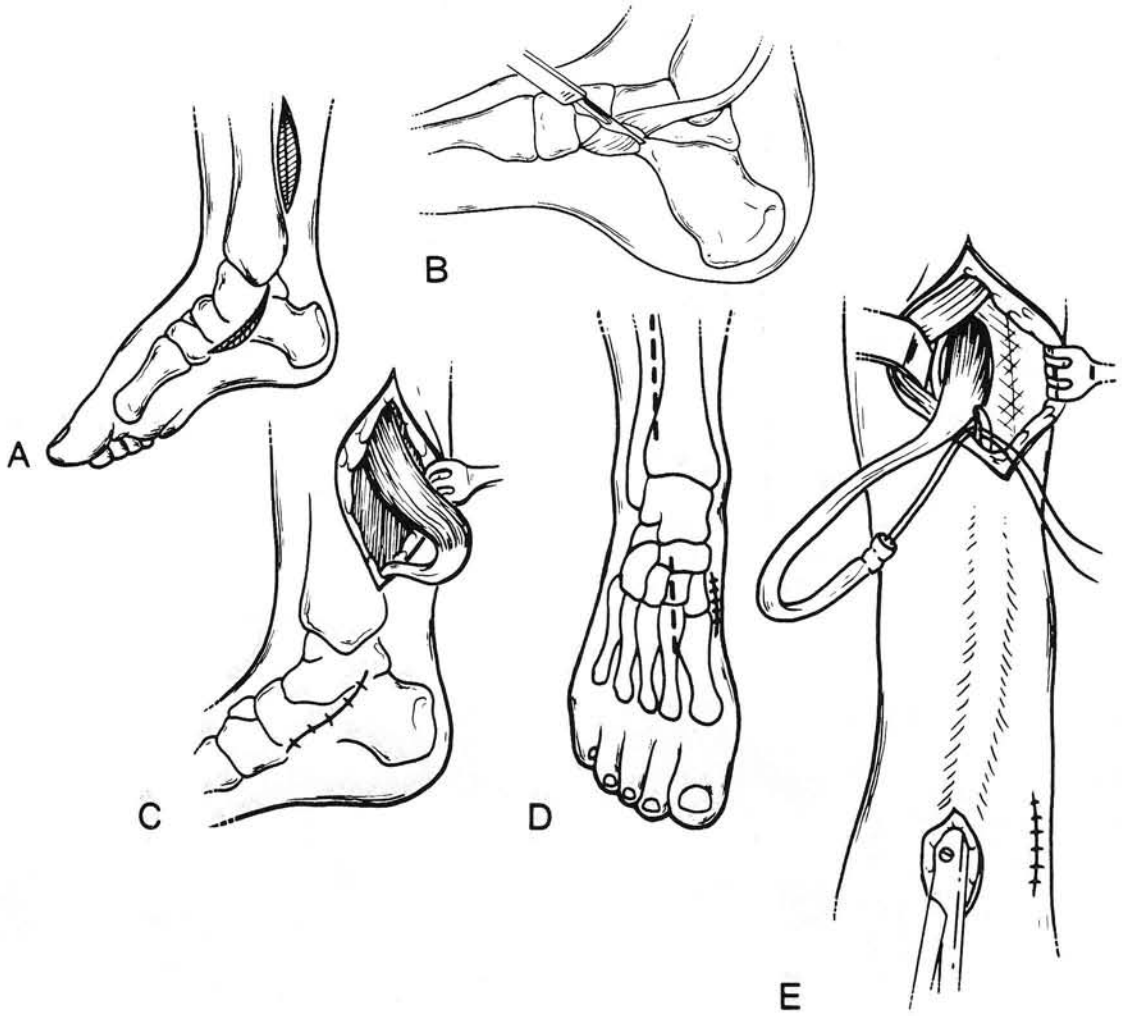

Fig. 7. Technique of tibialis posterior tendon transfer. Two incisions are used medially. **A. & B.** Distal incision is used to detach tendon. **C.** Tendon is retracted through to more proximal site. **D.** Incision is then made on anterior leg proximal to extensor retinaculum. **E.** Dissection is carried through interosseous membrane. Tibialis posterior is then passed posterior to tibia and anteriorly through interosseous membrane. It is then retracted distally to site of its new attachment. (Used with permission from McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery,* Williams & Wilkins, 1987.)

cannot be everted past the perpendicular. Where passive calcaneal eversion is not possible it is unlikely that tendon transfer will result in overcorrection.

This procedure is technically more difficult to perform and theoretically difficult to retrain as a functioning dorsiflexor due to its stance phase activity. However, our experience has shown that this is not a practical concern and adequate function is usually restored postoperatively. Tachdjian similarly notes that with vigorous postoperative care antagonistic muscles may be transferred effectively with good results (5).

Hibbs Suspension

The Hibbs suspension involves surgical release of the extensor digitorum longus from its insertion at the digits and transferring the tendon slips as a unit to the midfoot. The usual site of insertion is the third cuneiform or metatarsal (Fig. 8). The purpose of this procedure is to relieve excessive dorsiflexory force at the metatarsophalangeal joints. This may occur in patients with anterior equinus or other conditions with secondary extensor substitution. Other patients with a weak tibialis anterior will exhibit excessive compensatory function of the extensor tendon and further aggravate extensor substitution.

The Hibbs suspension may be helpful in select cases with flexible digital and forefoot deformity where good intrinsic muscle function is present. Following transfer the dorsiflexory power of the extensor digitorum longus may be slightly increased as dorsiflexory power is not expended at the digital and metatarsophalangeal joint level. However, in the patient with marked cavus deformity this pro-

cedure may be difficult to justify. In the idiopathic cavus foot intrinsic muscle function may be effectively eliminated due to the degree of deformity and the Hibbs suspension is not likely to encourage the return of normal activity. In recent years the Hibbs procedure has fallen into disfavor at this institution and has been performed in only selected instances.

Arthrodesis of the digital interphalangeal joints has become the treatment of choice for extensor substitution. Digital arthrodesis along with adequate extensor hood and metatarsophalangeal joint release typically provides thorough lasting correction of digital and the related plantar metatarsal buckling.

Jones Transfer

The Jones procedure involves detaching the extensor hallucis longus from its insertion and transferring it to a drill hole in the first metatarsal neck. It is used to relieve a cocked hallux deformity and performed in conjunction with a hallux interphalangeal joint arthrodesis. The hammered hallux may be a result of intrinsic muscle weakness and/or a weak tibialis anterior. By transferring the long extensor tendon proximally one is attempting to compensate for the excessive plantarflexory force of the peroneus longus and flexor hallucis longus tendons.

The effectiveness of the Jones procedure depends upon the flexibility of the first ray as well as the rearfoot. Sufficient dorsiflexion of the first metatarsal will not occur unless the ray is mobile. If the rearfoot is not capable of further pronation then dorsiflexion of the first ray may create further problems. Over correction following the Jones transfer may result in hallux limitus.

The Jones transfer is rarely performed at our institution. Arthrodesis of the hallux interphalangeal joint alone will assist the flexible first metatarsal in assuming a more physiologic position by relieving the retrograde forces at the metatarsophalangeal joint. Most surgeons at the Institute prefer to use a dorsiflexory first metatarsal osteotomy

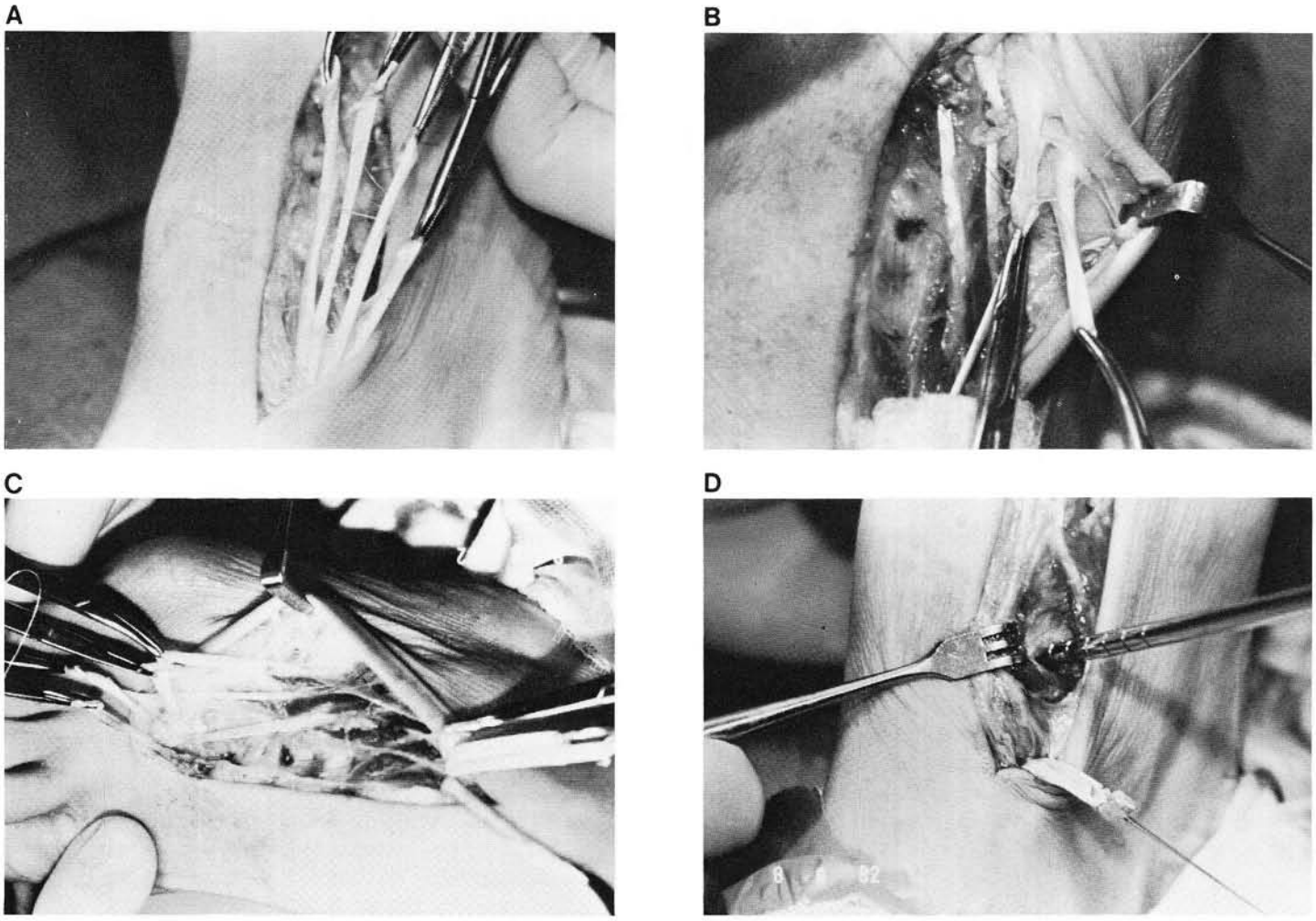

Fig. 8. Hibbs Suspension. **A.** Tendon slips of extensor digitorum longus are released at metatarsophalangeal joints. **B. & C.** Short extensor tendon slips are identified and anastamosed to the distal stumps of long extensor. **D.** Long extensor tendons are then combined and anchored into trephine hole in third cuneiform.

for additional correction as opposed to extensor transfer. Osteotomy appears to provide a more exacting correction of deformity, although the Jones suspension may work well in cases where there is weakness of the tibialis anterior. One may consider a more proximal transfer (base of the first metatarsal) in these instances.

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