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Common Peroneal and Posterior Tibial Nerve Paralysis

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INTRODUCTION

Loss of common peroneal function leading to paralysis of the anterior and lateral compartment muscle groups in the leg is common in leprosy.[27] The resultant foot drop leads to an abnormal compensatory high stepping gait and risk of ulceration to the (lateral) forefoot if there is concurrent sensory loss to the sole of the foot.[13] Brand described the anterior transposition of the tibialis posterior tendon (TPT) to the intermediate cuneiform, via a circumtibial approach.[7] Gunn and Molesworth reported fifty-six cases in which the tendon was taken via the interosseous route with insertion into the tarsal bones.[14] They reported good results in 49 cases but failed to describe the criteria for their results. Andersen published two papers in which five different procedures were described, including the interosseous route.[2,3] Thangaraj reported 50 cases using an interosseous approach with the transferred tendon inserted into extensor digitorum longus (EDC) and extensor hallucis longus (EHL).[26] Results were favourable, but it was noted that there was a decrease in range of movement compared to the Brand study. The focus at that time appears to be on resting position and range of movement rather then restoration of normal gait.

Srinivasan, in 1968, published a series with two aims:[25]

a) to simplify and attempt standardisation of the procedure and
b) develop criteria for assessing results.

He established standard criteria for measuring active dorsiflexion and range of movement. This was not correlated to function. Results showed improved dorsiflexion with concurrent Achilles tendon lengthening. Warren supported these similar findings in the same journal.[27] Warren also described the common post-operative problem of claw toes, which she attributed to compensatory tightening of flexor digitorum longus. She also described the problem of excess pronation in the immature foot following removal of tibialis posterior.

Carayon et al, reported on 23 cases in which a double transfer of tibialis posterior to tibialis anterior and flexor hallucis longus to EDC and EHL was done, both via the interosseous route.[9]

Warren reported complications such as osteopenia, leading to fracture and disintegration, and reaction with tendon to bone anastomosis.[27] Because of this complication a number of tendon to tendon insertions were described. Nowadays it is accepted that the first choice for correction of foot drop in leprosy and other peripheral neuropathies, is a tibialis posterior transfer via either the interosseous (IO) or circumtibial (CT) approach. A number of different tendon to tendon anastomosis are described. With isolated nerve loss to the anterior compartment of the lower leg and loss of the long toe extensors, the toes often lie plantar flexed. If these are mobile, they result in toe drop and this is usually corrected by routine TPT with insertion to EDC.

In addition to common peroneal nerve paralysis there is often function associated loss of posterior tibial nerve function leading to loss

of the intrinsic muscles of the foot. This paralysis leads to hyperflexion at the distal and proximal interphalangeal joints (claw toes), which may remain after TPT. In some cases a transfer of flexor to extensor tendon in the toe maybe required or if there is fixed non-correctable damage to the joints of the toe, fusion is indicated.

In the case of isolated posterior tibial nerve loss where the toe extensors are still functioning there is a tendency for the extensors to pull up the toes dorsally, while the intrinsics and other soft tissue structures contract and pull the toes plantar ward. This can lead to retracted toes.

COMMON PERONEAL NERVE PARALYSIS

Surgery versus Conservative Treatment

Surgical options and alternatives in common peroneal nerve impairment:

1) Untreated foot drop may result in contracture and the development of secondary deformities and ulceration. Therefore, if surgery is available, this should be the first choice.

2) **Steroids:** Multiple large studies have shown an improved rate of recovery of peroneal nerve palsy following a short-term course of steroids e.g. twelve weeks.[10] Success depends on the duration of the nerve involvement and whether it is complete or incomplete. Some studies have shown recovery with lesions up to one year. Greater likelihood of nerve recovery is in the partially impaired nerve, especially if the history of footdrop is less than twelve months.

3) Surgical decompression of the common peroneal (lateral popliteal) nerve: Some authors have recommended nerve decompression with the addition of steroids in early lesions. There is no clear evidence of the benefit of surgery in addition to steroids alone. However, benefit may be gained particularly when there is persistent nerve pain. (Chapter 3)

4) **Orthotics:** The use of orthotics helps to prevent contractures and secondary deformity and will facilitate normal gait. The use of a splint such as an ankle foot orthosis (AFO) prevents shortening of the Achilles tendon. Dynamic splints whether long (below knee) or short (ankle cuff) assist gait and maintain mobility pre operation (Fig. 14-1). There is also some evidence suggesting that there is improved recovery of the nerve if the foot is maintained in a normal position.[13]

Purpose of surgery: The main purpose of corrective foot drop surgery is to restore normal gait.[16,17] It is important, therefore, to view the affected foot in terms of disrupted biomechanics. If concurrent to the motor loss, there is diminished protective sensation to the sole, the

FIGURE 14-1 Dynamic foot drop splint.

foot is at increased risk of developing ulcers. In footdrop with a plantar grade foot and a tendency to equinovarus there is increased pressure loading on the lateral border and forefoot. Following corrective surgery heel strike is restored and the loading is changed, which will result in decreased lateral border and forefoot ulceration. Some authors have suggested that surgery does not affect the frequency of ulceration merely the distribution.

Functional Anatomy

Nerve supply

The muscles of the anterior and lateral compartments of the leg are supplied by the common peroneal (lateral popliteal) nerve. The nerve passes down obliquely through the lateral side of the popliteal fossa, travels between the tendon of biceps femoris and the lateral head of gastrocnemius then wraps around the fibular neck before dividing into deep and superficial branches. Rarely (1%) the nerve divides into its two branches proximal to the fibular neck. Adkison found that the course of the superficial peroneal nerve is more variable than commonly thought.[1]

The superficial branch supplies the peroneous longus (PL) and brevis (PB) then the skin over the lateral aspect of the lower leg onto the dorsum of the foot, except the 1st web space. Paralysis of this branch causes weakness of eversion of the foot and sensory loss.

The deep branch supplies the anterior muscle groups, Tibialis Anterior (TA), Extensor Hallucis Longus (EHL), Extensor Digitorum Communis (EDC) and Peroneus Tertius (PT), dividing into medial and lateral branches before finishing in a terminal branch supplying sensation to the first web space on the dorsum of the foot. Paralysis leads to lack of dorsiflexion of the ankle and minor sensory loss. The nerve also supplies the dorsal intrinsic muscles of the foot: extensor hallucis brevis and extensor digitorum brevis.

Muscle actions

The anterior muscle group passes in front of the axis of the ankle joint and dorsiflexes the ankle. The prime mover of dorsiflexion in a neutral plane is tibialis anterior. Extensor hallucis longus and EDC act as secondary dorsiflexors of the ankle. Peroneus tertius has the additional role of everting the foot and acts with the peroneal group to prevent forced inversion of the forefoot on dorsiflexion. This helps the foot to maintain its normal gait pattern without striking excessively on the lateral boarder. The range of movement and power of dorsiflexion depends on the length of the moment arm and excursion. Tibialis anterior and EHL have a short moment arm and long excursion (3 to 5 cm).[22] This compares to the tibialis posterior with an excursion of 2 cm. There is an inverse relationship between moment arm and excursion. A long moment arm gives a smaller excursion or range of movement but more power.[8]

Tibialis Posterior Muscle

The Tibialis Posterior arises from both the tibia and fibula and the interosseous membrane between flexor digitorum longus (FDL) and flexor hallucis longus. It passes deep to these muscles in the lower leg sharing a common groove with FDL behind the medial malleolus but in a separate sheath. It then passes inferior to calcaneo-navicular ligament contains a sesamoid bone and then divides into two slips. The larger, superficial and medial division, inserts into the tuberosity of the navicular and medial cuneiform. The smaller, deeper and lateral division gives tendinous slips to the intermediate cuneiform and base of the 2nd, 3rd and 4th metatarsals.

Biomechanical considerations

A full biomechanical understanding of the nor-

mal foot is important to understand stability of the foot in standing and the transfer of forces during gait phase (Chapter 12). Biomechanical considerations are required in understanding changes that occur with nerve involvement e.g. foot drop and the alteration occurring from tendon transfer e.g. hind foot instability from tibialis posterior detachment.

Pathogenesis of nerve damage

Damage of the common peroneal nerve in leprosy may result in paralysis of all the muscles in the anterior and peroneal compartments. The paralysis leads to loss of ankle dorsiflexion, foot eversion and toe extension and produces footdrop, toe drop and a tendency toward equinovarus deformity. Most commonly, both the superficial (peroneal compartment) and deep (anterior compartment) are involved. However, either branch can be spared particularly where there is variable anatomy. If a single branch is involved this is most commonly the deep branch, leading to isolated paralysis of the ankle dorsiflexors with intact inversion and eversion.[21] Less commonly the superficial branch can be singularly involved maintaining dorsiflexion with weakness of eversion. Antia describes the pattern as beginning distally with involvement of the great toe extensor then the lateral four toes.[4] This progresses proximally to affect the prime dorsiflexor of the ankle. Fritschi describes a small residual group where the pattern is variable and extensor hallucis longus may be spared leading to weak dorsiflexion of the ankle as a secondary action to the prime movement of hyperextension of the great toe.[12]

Structure and Function loss

Primary deformity

Loss of the common peroneal nerve in leprosy leads to loss of dorsiflexion resulting in foot drop. The resting position of the foot is plantar flexed and inverted. Where the superficial branch is not affected the muscles of the lateral compartment, peroneus longus and brevis, are spared maintaining eversion. Losses of the long extensors of the toes, EHL and EDC, results in drop toes. The affect of this paralytic deformity is an alteration of gait, characterised by exaggerated ankle equinus and increased hip and knee flexion during the swing phase of the walking cycle.[21] The function of the anterior muscles is to dorsiflex the foot allowing clearance of the forefoot and normal heel strike. With these muscles paralysed the foot hangs down in normal gait and to compensate the person exaggerates the lift, as in climbing steps, to avoid tripping over the forefoot. This is known as a "high stepping" gait. With the foot inverted and plantar flexed, strike tends to occur on the lateral border making it susceptible to damage. There is also instability around the ankle and subtalar joints, on weight bearing, as the contralateral leg moves through its swing phase.

Secondary deformity

Secondary shortening of the Achilles tendon can occur as a result of longstanding untreated foot drop. Early intervention with mobilisation, active splint (e.g. footdrop spring) and stretching can prevent this. If left, the foot will tend into plantar flexion and inversion. This may result in a stiff foot with an equino-varus deformity. Long standing plantar flexion leads to contracture of the intrinsic muscles of the foot. If this is associated with posterior tibial nerve loss then clawing of the toes can occur. In these situations clawing needs to be addressed, as well as restoring active dorsi-flexion of the ankle.

Inclusion criteria for Tibialis Posterior Transfer

Listed are consensus guidelines for suitability of a limb for TPT, in addition to the standard criteria for tendon transfer surgery as outlined

in Chapter 1.

1. Ankle joint: Following preoperative physiotherapy, a minimum of 10 degrees of dorsiflexion from neutral with the knee flexed is required. Due to the post operative loss of resting position of an average of 10 degrees over the first year following surgery, a minimum passive dorsiflexion is required.[16] This is measured with the knee bent to eliminate the effect of gastrocnemius tightening.

2. Neuropathic foot: No evidence of active neuropathic bone disintegration (NBD) for a minimum of three months following the completion of trial walking.[16] The stress of surgery can lead to a flare up of any unresolved NBD. Postoperative immobilisation in a cast can lead to osteopenia and precipitate NBD.

3. Dorsiflexor weakness: Dorsiflexor or evertor weakness MRC 0-2. Grade 3 or more can lead to a functional gait.

4. Use of crutches: Able to mobilise with crutches or a walking frame. This is critical to successful postoperative re-training.

5. Self-care: Demonstrated ability to look after skin of affected limb. In a limb with anaesthetic sole, patient directed self care of the limb must continue postoperatively for life.

Pre-operative Physiotherapy

The success of the TPT procedure is critically dependent on quality pre- and postoperative physiotherapy. The physiotherapist role in management and as part of the surgical team in decision making such as timing of surgery and discharge is essential. An extensive description of physiotherapy management and assessment is not possible here (see chapter 21). Presented are key features specific to TPT. All the exercises should be taught to the patient to facilitate these on an ongoing basis.

1. Assessment: Assessment should include both the patients and surgeons perspective. It is important to determine whether the patients' requirement is one of appearance or function and how this affects the activities of daily living or a particular occupation.

2. Flexor tendon tightening of the long flexors of the toes can result in clawing and these need to be assessed and treated (see claw toes).

3. Isolation of transfer: Tibialis Posterior needs to be isolated and 'strengthened'. This will facilitate postoperative re-education.

4. Balance exercises: This improves proprioception and stability of the subtalar joint.

5. Use of crutches: Demonstration of the use of crutches and modification when there is concurrent hand disability speeds the postoperative recovery.

6. Footwear: Measurement for any special footwear needed post operatively.

Achilles Tendon Lengthening (TAL)

Introduction: Achilles tendon tightening is a common feature of persistent foot drop. The indications for Achilles tendon lengthening in the literature are not clear. Early literature recommended lengthening where there was more then residual restriction to passive dorsiflexion after pre operative stretching.[25] Review of failure and recommendations by the group involved in the neurologically impaired foot workshop suggested that one of the most common contributors to a poor result is failure to adequately lengthen the Achilles tendon.[16] They recommended that TAL should be routinely done with all TPT's.

Closed versus open: Two techniques are avail-

able to the surgeon for TAL. They are 1) Closed or percutaneous method and 2) Open or commonly called Z-lengthening. No long-term studies comparing these two methods have been published. The closed approach is relatively simple, quick and has low associated morbidity. The advantage of the open technique is that maximum passive dorsiflexion can be guaranteed. However, there is increased morbidity associated with a surgical wound in the paratendon Achilles region due to poor blood supply. Using a closed technique up to 30-40 degrees of passive dorsiflexion with the knee flexed should be achieved following surgical release.

Closed technique: Closed technique consists of a sliding lengthening. Under anaesthetic with the knee straight and the foot held in forced dorsiflexion resting on the surgeon's hip a percutaneous Achilles tendon lengthening is made. Using a size 11 or 15 blade a stab incision is made in the distal medial half of the tendon 1 cm above its insertion into the calcaneum. A second proximal lateral stab incision is made at the musculo-tendinous junction. With continued forced dorsiflexion the fibres of the Achilles tendon are allowed to slide. This results in a passive dorsiflexion of at least 30 to 40 degrees from neutral. The tendon is palpated externally to ensure continuity proximally and distally. The principle of this procedure is to allow a slide of the fibres within the tendon sheath without complete rupture of the tendon. This procedure is well described in children with spasticity in the Achilles tendon due to e.g. Cerebral Palsy.[5,23]

Open technique: When there remains posterior capsular tightening after exercises or maximum length needs to be ensured, then a standard open Z-lengthening can be performed. Careful placement of a concave curved incision posterior medial above the medial malleolus can allow both access to the Achilles tendon and retrieval of tibialis posterior for tendon transfer. As per the closed technique after opening the tendon sheath the Achilles tendon is divided through half its bulk both proximal-lateral and distal-medial and then split down its length.[23] The two ends are then sutured side to side for one to three cms.

Tibialis Posterior Transfer: technique

Interosseous route: Under spinal or general anaesthetic the patient is placed in a supine position and an above knee tourniquet is applied. An Achilles tendon lengthening procedure is first performed. If an open lengthening is done then the same incision can be extended, curved proximally and medially to allow for both delivery of the tibialis posterior tendon, and access to the interosseous space. An 8 cm curved or straight incision is made starting one to two finger breadths proximal to the medial malleolus in the line of the tendon. The tibialis posterior tendon is exposed lying deep to the tendon of flexor digitorum longus. Care is taken not to damage the long saphenous vein or the saphenous nerve. A skin crease incision is made just proximal to the tibialis posterior insertion to the navicular on the anterior-medial aspect of the ankle. At this level it is easily palpable. The tendon insertion is exposed and an artery forceps placed across the tendon with the foot adducted. The correct tendon is confirmed by pulling on it above the malleolus. The tendon is then divided at its insertion, freeing both superficial and deep attachments to maintain length. In the incision proximal to the medial malleolus, a digit or blunt instrument is placed under the tibialis posterior tendon just distal to the musculo-tendinous junction and the tendon is delivered into the wound. It is important to try and avoid stripping the distal muscle fibres directly off the tendon. By blunt

dissection the tibialis posterior tendon and its muscle unit is stripped off its origin from the tibia in the middle third of the calf, mobilising the complete unit. The adequacy of the interosseous space can often be determined at this stage. An eight cm longitudinal incision is made over the anterior aspect of tibialis anterior 1-cm posterior to the prominence of the anterior tibial border in the distal half of the middle third of the calf (Fig. 14-2). Using a pair of long dissecting scissors a complete fasciotomy is performed. By blunt dissection and a right-angled retractor the muscle of tibialis anterior is retracted to expose the interosseous membrane. Care is needed not to tear the deep veins as haemostasis is difficult and subsequent bleeding can lead to adhesions as the tendon passes through the interosseous space. A small incision is made in the membrane, and this is extended by blunt dissection as far proximal as possible. At this stage it is important to confirm the suitability of the interosseous space for the transfer. The space narrows distally and can sometimes be irregular on its tibial surface. The tip of a little finger should pass easily through this space. Some authors advocate a pre operative X-ray of this space as a guide, but this has not been standardised. Should there be excess irregularity or the space very narrow then the interosseous approach should be changed to a circumtibial at this stage.

A large curved Anderson tendon tunneler is passed through the interosseous space and around the posterior aspect of the tibia. The tibialis posterior tendon is then brought into the anterior compartment and under tibialis anterior to lie lateral to it. This decreases the possibility of adherence between the raw muscle fibres of tibialis posterior and the surface of the tibia. At this stage it is useful to check that there is sufficient length to reach the tendons over the anterior aspect of the ankle. If insufficient length is present then further stripping of the muscle of tibialis posterior from its bony origin may be required. The wounds on the medial aspect of the leg are irrigated and closed.

Transverse skin crease incisions are made over the distal portion of the anterior aspect of the ankle after palpating the tendons (Fig. 14-2). A number of options of insertion exist. The author's preferred method is a two-slip tendon to tendon anastomosis, the medial slip to TA and EHL with the lateral slip to EDC and PT. The tendons are identified by sharp dissection, and a stay loop or towel clip is passed around the tendons.

The tendon of tibialis posterior is split longitudinally to the point where the distal muscle fibres insert. A buried suture is placed inside the base of these two slips. This stops the slips from separating further during the attachment or at the time of mobilisation thus maintaining the tension on the slips.

A subcutaneous tunnel is made superficial to the extensor retinaculum using long blunt tendon tunnellers. With care to avoid twisting the two slips they are passed using tendon tunnelers to the two distal incisions over the ankle. It is important to check that these tunnels are free from restrictions and the tendon slips move freely. This can be done by blunt digital dissection from proximally to distal.

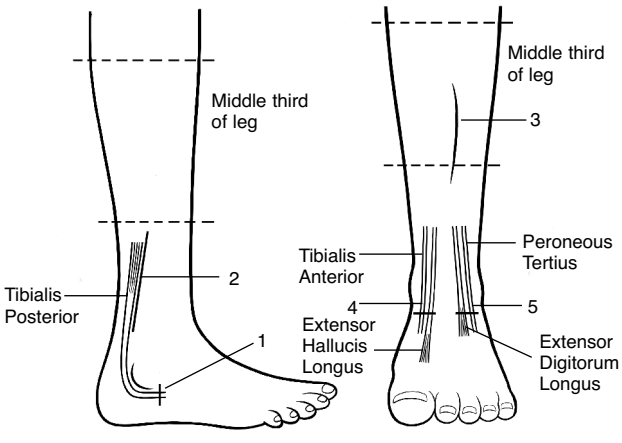

FIGURE 14-2 Skin incisions for TPT.

With the knee flexed the ankle is held in at least 20 degrees dorsiflexion, (by an assistant or using a Fritschi splint) the tendons are anastomosed using a double weave technique (Fig. 14-3). The lateral slip is weaved through Peroneus Tertius and EDC from lateral to medial to lateral. This should be done with the tension on Peroneus Tertius initially and then to EDC at neutral tension. This should utilize the transmitted force to dorsiflex the ankle rather than extending the toes, which can increase the clawing deformity. The two weaves should be in different planes, preferably at right angles to stop the weave becoming single. The lateral slip is pulled through and sutured at maximum tension using a 2/0 suture. The medial slip of tibialis posterior is then sutured in neutral tension after double weaving through tibialis anterior and EHL (medial to lateral to medial). This helps to keep the two slips divergent and increases the mechanical balance acting on the foot. The ends of the tendon slips are then buried under the extensor retinaculum.

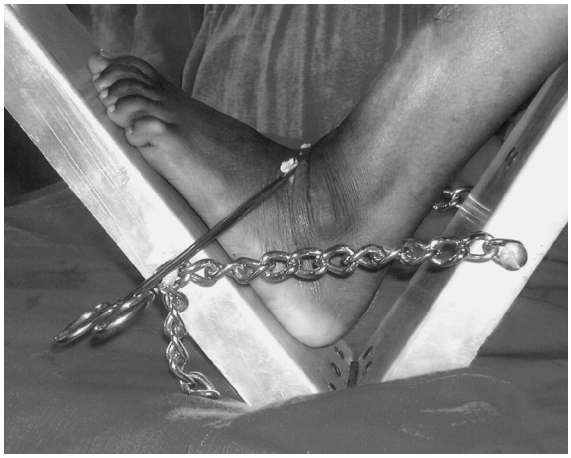

FIGURE 14-3 Footdrop splint.

With the knee flexed the foot is released and its position checked. Richard reported a loss of 10 degrees between splint and release angle.[22] A further loss of 10 degrees in the first year post operative suggests there should be a resting position of at least 20 degrees dorsiflexion.[16] The foot should also be in neutral or mild eversion. If the position is not satisfactory then the slips should be adjusted on the table.

The wounds are dressed and a below knee cast applied with the foot in neutral and 15 to 20 degrees of dorsiflexion for 3-4 weeks, after which physiotherapy is commenced (see Chapter 21).

Circumtibial route: The principle of the circumtibial approach is the same as the interosseous except the tibialis posterior tendon doesn't pass through the interosseous canal into the anterior compartment. It is critically important to maximise vertically the angle the tendon takes into the foot to mechanically mimic the action of the anterior group of muscles. The operation proceeds as per interosseous approach with an Achilles tendon lengthening and the Tibialis Posterior tendon released from its insertion to the navicular. Incisions and stripping of the Tibialis Posterior are as described for the interosseous approach, except that the lateral calf incision is not used. A subcutaneous tunnel around the anteriormedial aspect of the lower tibia is made, superficial to tibialis anterior and the extensor retinaculum to the dorsum of the ankle. This must reach the midline at least 5 cm above the ankle to ensure a good angle of pull. The tendon is then split into two slips and passed separately or split after passing to the ankle. The procedure then continues as per interosseous route. Some authors have found a tendency to delayed inversion deformity.[24] This can be avoided by careful tunnelling from as high as possible and attention to the tension of the slips while suturing the anastomosis.

Insertion

1. Single versus Double: Antia recommended the use of a single slip passed either via

interosseous or circumtibial route. Insertion was into the soft tissues over the tarsus, where pulling on these tissues with forceps brings the foot into neutral.[4] This is difficult to balance and can lead to an inversion or eversion deformity. Srinivasan described a high division of tibialis posterior into two slips, feeding them through separate subcutaneous tunnels and inserting into EHL and EDC.[25] Thangaraj recommended a division more distally with insertion into tibialis anterior and laterally to EDC.[26]

2. Moment arm: The moment arm of a tendon crossing a joint determines the range of movement and the power that tendon can generate.[22] In essence the more distal the attachment of tendon into the dorsum of the foot the longer the moment arm resulting in increased power but decreased range of movement.

3. Strength of insertion: It is now well accepted that a double weave technique, as described by Pulvertaft, leads to a strong tendon to tendon anastomosis and this is recommended.

4. Range of movement: Range of movement is determined by the excursion of the tendon, moment arm, and mobility of the ankle joint. Ankle joint movement is affected by lengthening of the Achilles tendon, ankle capsular tightness and joint surfaces.

5. Options: Multiple authors have described insertion of tendon slips into all the extensors over the dorsum of the foot. Consistently a slip is inserted into tibialis anterior and variably also extensor hallucis longus to provide medial pull, and extensor digitorum communis (EDC) variably including peroneus tertius to provide lateral pull. The involvement of peroneus tertius may counteract the tendency to the post-operative clawing seen where EDC alone is used. Some authors have advocated a slip to peroneus brevis to counteract any tendency to inversion.[24,27] This can if overcorrected produce the opposite eversion deformity. Both inversion and eversion should be avoided. The individual choice of insertion should result in a balanced foot dorsi-flexing in a neutral plane, with adequate range of movement and no secondary effects e.g. cocked great toe.

6. Tendon-tendon versus bone: Initially to gain rigid attachment the transferred tendon was inserted through a hole in the middle cuneiform. Harris and Brand reported that this could lead to osteopenia and predispose to neuropathic degeneration.[15] Post-operative immobilization time is also prolonged. As a result tendon to tendon anastomosis is strongly recommended.

Brand describes tendon-tendon anastomosis are strong enough for careful movement at 3 weeks, reasonable at 4 weeks and against resistance at six. Where there is inadequate or inexperienced physiotherapy or poor patient compliance, it may be beneficial to leave the initial cast on for six weeks to ensure strong fibrosis at the anastomosis. The balance between strong anastomosis, to prevent rupture, and early movement, to prevent adhesions, needs to be judged.

Management of Complications

Lack of dorsiflexion: The restoration of normal gait is related to the resting position of the foot and the range of movement. The larger the range of movement, provided this allows for dorsiflexion above neutral, the better the gait. However even a small range of movement (5 degrees) can be functional. It has been suggested that active dorsiflexion post transfer of a minimum of 5 degrees above neutral is required. Allowing for a 10 to 15 degree drop in the first post operative year if there is not active dorsiflexion to 5 degrees above neutral then

either a heel raise on the shoe or a further procedure should be considered.[22] A significant contributor is contraction of the Achilles tendon. This should be considered to be lengthened routinely.[16,21,22] Options where the tibialis posterior tendon slips appear long include a) Reefing the tendon. This allows for shortening without dividing the tendon, b) reinsertion of the tendon taking up any residual slack, c) shifting the anastomosis distally.

Residual inversion/eversion: Both inversion and eversion should be avoided.[12,13] However inversion is a more common complication and can lead to excess pressure on the lateral boarder of the foot and increased incidence of ulceration. In the first instance it is simplest to rebalance the foot with reefing or reinsertion of the lateral slip or shifting the single slip more laterally. Soares found that this complication was more common in circumtibial procedures.[24] Other authors have not supported this and it may be a result of the tibialis posterior tendon wrapping around the tibia too distally with the line of pull medially rather then vertically. If rebalancing is insufficient Soares recommends an extra graft from the lateral slip to the insertion of peroneal brevis.[24] Warren describes dividing peroneus brevis just proximal to the lateral malleolus leaving its insertion attached, re-routing it to the dorsum of the ankle, weaving it through the tibialis posterior tendon where it is inserted into extensor digitorum communis and attaching it again distally to the periosteum over the neck of the 5th metatarsal (personal communication). This effectively acts as a sling to help evert the lateral aspect of the foot.

Lack of Range of movement: Minimal range of movement can be due to

a) Adhesions
b) Poor patient motivation
c) Decrease in muscle power.

Adhesions between the interosseous space and tibialis posterior muscle can be minimised by ensuring haemostasis during operation to minimise haematoma, by ensuring adequate space by intra operative assessment and not taking the muscle through the narrow space distally. The most common places for the tendon to adhere is in the interosseous space, if passed low, or in the subcutaneous tunnels. These need to be adequate with no fibrous septae and a long fasciotomy. Should adhesions occur early, active mobilisation or friction therapy are indicated. If they occur late then they may require surgical release.

Poor gliding is often found around the ankle. Tunnelling superficial to the extensor retinaculum will decrease this. Some authors have noticed bowstringing, but this is generally cosmetically acceptable.

Again a full superficial fasciotomy proximally and distally is required. Oomen describes the rare event of paralysis of the transferred muscle due to precipitation of acute neuritis of the medial popliteal nerve (tibial nerve) following surgery.[21]

Poor gait: A small proportion of patients neglect to use the transferred tendon and persist with a high stepping gait. In this case a period of intense retraining with the knee straight and particularly focusing on gait is useful.

Secondary claw toes: It is important to assess the degree of clawing pre-operatively (see section on claw toes) Restoring dorsiflexion with pre-existing tightness of the intrinsic muscles of the foot and shortening of the long flexors will increase the degree of clawing. Marked clawing whether passively correctable or not should be corrected at the time of TPT. Mild clawing is usually not symptomatic. Moderate clawing commonly requires correction, which can be done at the time of TPT or delayed until

assessment following the TPT.

Hind foot instability: The detachment of the Tibialis Posterior tendon from the site of insertion deprives the foot of pronatory action and support of the medial longitudinal arch. This can potentially lead to hind foot instability. Cross, suggests that a medial stabilizing orthosis (or 'Hati' pad) may be beneficial.[11]

Reverse Metatarsal arch: Reversed metatarsal arch can result in hyper-extended metatarsophalangeal joints, increasing the risk of ulceration under the metatarsal heads. Srinivasan has advocated proximal shifting of EDL to the metatarsal neck, sometimes combined with fusion of PIP joints, and shaving off the plantar aspect of the head of the metatarsal.[16] This he recommends as an alternative to metatarsal head resection.

POSTERIOR TIBIALIS PARALYSIS

Rarely in leprosy the posterior tibialis is paralyzed. This is more common in polio or trauma. If all muscles below the knee are paralysed, the result is a flail foot, which tends to flap on walking. Hypermobility of the foot leads to a) compensatory high stepping gait, b) risk of plantar ulceration consequent to abnormal strike during gait and c) instability of the ankle during weight bearing. Treatment ranges from conservative splinting to permanent arthrodesis.

Orthotics

The two keys of orthotic or splinting management are control of the unstable ankle and subtalar joints. Instability is much greater when the gastrocnemius is also paralysed. There is a tendency for marked pronation of the hind foot and this can be limited by the use of a medial stabilising pad such as a “Hati” pad (Chapter 17). However this is seldom sufficient and the support of a calliper or a fixed ankle brace will usually be required (Chapter 23). Ankle instability requires a minimum of an ankle foot orthosis (AFO). This simply acts as a fixed back slab and helps prevent tightening of the Achilles tendon. However, this too is generally insufficient and the addition of a stable above ankle boot is required. If despite a stable boot and AFO there is continual tendency for the hind foot to roll into pronation then a fixed ankle brace is recommended.

Tenodesis

Stability to control the degree of passive dorsi and plantar flexion of the foot at the ankle can be achieved by tenodesis. Tenodesis maintains ankle flexion while preventing toe drag during the swing through phase of gait. It also helps stabilise the hind foot giving increased stability on weight bearing and during heel strike.

The principle of this surgery is to give the foot two sets of guy ropes to hold the foot plantar grade at rest but allow passive dorsi- and plantar flexion during gait.

Technique: An open Z-plasty of the Achilles tendon is performed with the addition of a posterior ankle capsulotomy if required to allow passive dorsiflexion to 15 – 20 degrees. The tendons of tibialis anterior and peroneus brevis are divided at their musculotendinous junctions in the middle third of the leg and brought out at the point of their insertions in the foot. They are then tunnelled subcutaneously and superficial to the extensor retinaculum to the tibia at the junction of the middle and lower thirds. The tendon of tibialis anterior is passed medial to lateral through a transverse drill hole in the tibia. It is then double weaved through the tendon of peroneus brevis with the foot held at 15 degrees of dorsiflexion (Fig. 14-4). The tendon is further sutured to the tibial periosteum on both sides to encourage adhe-

sions. An initial padded cast subsequently changed to a total contact cast is applied for a total of eight weeks. Following the removal of the cast the patient is mobilised with crutches until stable and safe during walking. Minimal physiotherapy is generally required. The foot should be protected in a resilient shoe and the posterior half of the cast used for three months

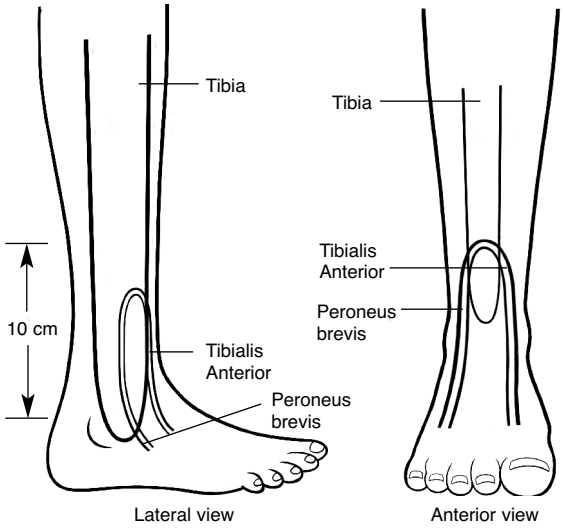

FIGURE 14-4 Tibialis anterior/ peroneus brevis tenodesis for foot drop.

at night to prevent passive stretching.

This procedure seems to work best when there is no gross ankle instability. When the gastrocnemius is still functional it will tend to stretch significantly with time. When the ankle is grossly unstable a tenodesis alone is unlikely to provide long-lasting stability to the foot.

Half gastrocnemius split

Where there is marked paralysis of the lower limb, the gastrocnemius/soleus group frequently remains the only functional muscle for tenodesis. Transfer of one head of gastrocnemius balances the muscle function across the ankle. Warren describes a modification of the Caldwell procedure (personal communication).[28] It is also described for patients with gastrocnemius paralysis , but it would be likely to stretch significantly with time in this situation.

Technique: The medial half of gastrocnemius/soleus complex is split down to its calcaneal insertion. It is then transferred by a circumtibial route through the tibialis anterior tendon and attached to the peroneal brevis tendon after division at the ankle and re-routing back to the dorsum of the ankle. A lengthening Z-plasty is performed on the remaining half of the Achilles tendon, to allow a minimum of 15 degrees of dorsiflexion from neutral. There is a tendency to secondary development of clawing of the toes and a flexor to extensor transfer (Girdlestone) is advised to be performed concurrently. If there remains marked equinovarus deformity of the hind foot Wolf et al advised a concurrent Dwyer calcaneal osteotomy.[28] The procedure acts as an ankle stabilizer. Actual control of the ankle will be minimal. A period of eight weeks in a cast with the foot dorsiflexed is advised to ensure adequate fibrosis.

Arthrodesis

In some patients following a tenodesis there will be persistent instability of the subtalar and ankle joint. In others bony or joint destruction limits the passive range of movement even after Achilles tendon lengthening and capsulotomy. In these cases a more extensive procedure is required. A triple fusion may be adequate, possibly combined with a tenodesis. This stabilises the subtalar joint (preventing excessive pronation) the talar-navicular and calcaneal-cuboid joints. Barr advocated a tendon sling using tibialis anterior and peroneus longus combined with a triple arthrodesis to prevent inversion.[6] In leprosy it is common to have collapse at the midtarsal level with abduction or adduction of the forefoot. Corrective osteotomy of the talar-navicular joint and calcaneal-cuboid joints corrects this,

giving stability of the forefoot on weight bearing and making the wearing of footwear easier. The triple fusion leaves the ankle joint free and assists walking. X-rays with the foot in full forced varus and valgus will help determine whether the instability is principally in the subtalar or ankle joint. Especially in early onset neuropathy such as polio the instability can be principally in the ankle joint. In this situation or where there is additional significant destruction of the ankle joint, the ankle joint can be fused as a pan-talar fusion (Chapter 13).

TOE DEFORMITY IN NEUROPATHY

Pathogenesis

The Posterior Tibial nerve and plantar nerves are commonly damaged in leprosy.[21] It is vulnerable posterior to the medial malleolus where being superficial, it is susceptible to repetitive trauma and constriction within the Tarsal tunnel. This leads to plantar anaesthesia and "clawing" of the toes. Early clawing is often unrecognised and neglected. Late fixed clawing alters the normal biomechanics of the forefoot increasing the risk of ulceration. Where there is concurrently lateral popliteal nerve palsy with drop toes there is a tendency to more severe clawing due to contracture of the intrinsic muscles of the foot. Early mobile clawing can be treated conservatively with good foot care. A Kelikian push-up test helps assess the flexibility of a lesser toe deformity.[19] More extensive involvement requires surgical intervention.

Classification

Classification is based on either anatomical appearance or pathologic progression.

Anatomical Appearance

1 **Hammer toe:** Dorsiflexion of the proximal phalanx at the metatarsal phalangeal joint (MTPJ) with the proximal interphalangeal

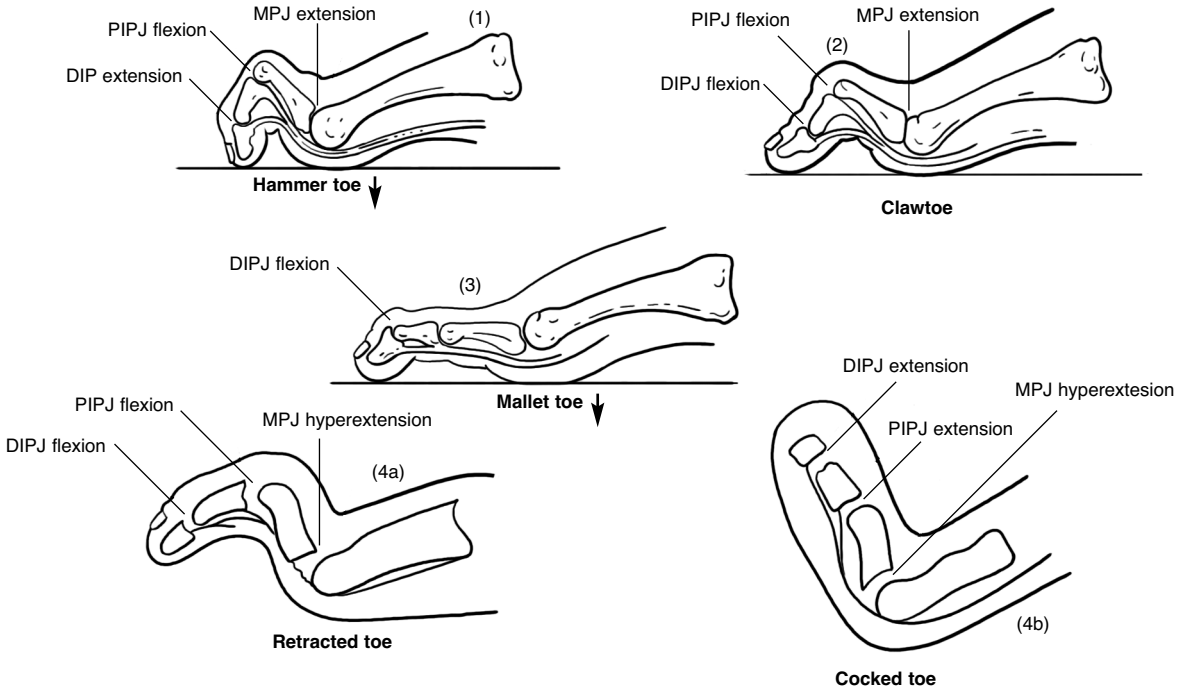

FIGURE 14-5 Classification based on anatomical variance.

joint (PIPJ) in neutral or plantar flexion and dorsiflexion of the distal interphalangeal joint (DIPJ) with the pulp of the tip on the ground (uncommon in leprosy).

2 **Claw toe:** As per hammer toe but the DIPJ is plantar flexed with the nail tip on the ground.

3 **Mallet toe:** Plantar flexion of the DIPJ only with rest in neutral (uncommon in leprosy).

4 **a) Retracted toe:** As per claw toe but the tip does not touch the ground during weight-bearing due to excessive dorsiflexion at the MTP joints.

b) Cocked toe: If the DIP joint is dorsiflexed this is sometimes called a cocked toe.

Pathologic progression

Antia describes three progressive stages from normal.[4] (Fig. 14-6)

a) 1st stage: Dorsiflexion at the MTP joints; plantar flexion PIP joints and DIP joints with the tip of the toe on the ground during weight bearing. This can lead to an ulcer on the tip.

b) 2nd stage: Increased dorsiflexion of MTP joints and plantar flexion of PIP joints. The DIP joints may be in neutral. The tip usually does not touch the ground during weight bearing and there is risk of ulceration over the dorsum of the PIP joints.

c) 3rd stage: Hyperextension at the MTP joints thinning the soft tissues and increasing pressure over the plantar aspect of the MTP head resulting in an ulcer.

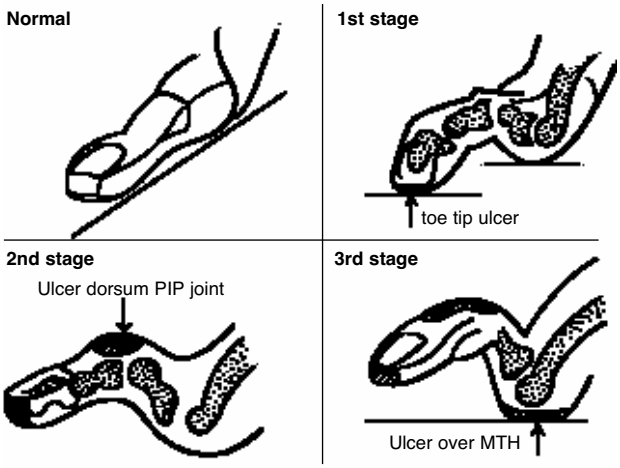

FIGURE 14-6 Progressive stages from normal in claw toe deformity (modified from Antia[4]).

Management

Orthotics

For more information on orthotic devices that can be useful in correction of paralytic deformity and management and prevention of plantar ulceration see chapters 17 and 23.

Surgery

The appropriate surgery depends upon the type of deformity.

Correction of hammer toe

1) In mild deformity where there is no concurrent joint contracture a flexor to extensor transfer (Girdlestone procedure) is recommended.
2) In moderate deformity where there is limitation of the PIP joint a resection of the distal half of the proximal phalanx is advised. In addition a percutaneous tenotomy of extensor digitorum longus may be required.
3) In severe deformity where there is limitation of the PIP joint and often contracture and hyperdorsiflexion of the MTP joint, a resection of the distal end of the proximal phalanx or a PIP joint fusion is required. In addition soft tissue and joint contractures require release as well as tenotomy or lengthening of extensor digitorum longus.

Correction of Claw Toes

Flexor to extensor transfer

Flexor to extensor transfer, or Girdlestone procedure, is indicated for mobile claw toes. If there is joint capsule tightness this can be released at the same time to mobilise the PIP joints.

Technique

Under anaesthesia a curved S-shaped incision is made over the dorsum of the proximal phalanx extended distally over the lateral aspect of the toe to just past the DIP joint. The tendon of

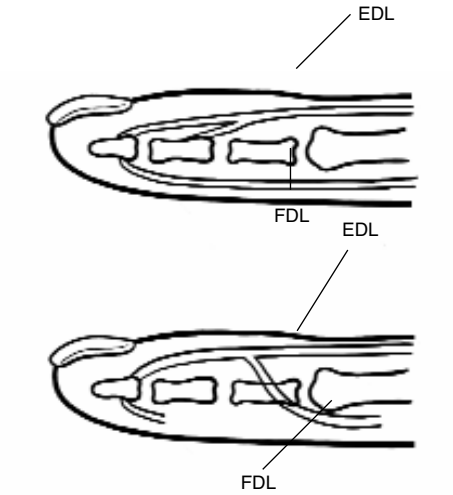

FIGURE 14-7 a. Showing pre-operative anatomy. **b.** FPL has been divided and transferred to dorsum of toes and sutured to EPL.

flexor digitorum longus is detached from its insertion and reinserted into the extensor tendon over the proximal phalanx with the toe held in neutral (Fig. 14-7).

Any restriction to extension of the PIP or DIP joints should be corrected by soft tissue release or capsulotomy. Often vigorous forced manipulation is sufficient to achieve this. The effect is to flex the metatarsal phalangeal joint and extend the PIPJ. Immobilisation can be achieved by a temporary fine longitudinal K-wire, a hypodermic needle placed longitudinally in the soft tissues, or a plaster cast for three weeks.

The patient is mobilised with heel walking for three weeks then footwear with micro cellular rubber insole should be used to distribute the weight bearing over the distal forefoot.

Arthrotomy/Tenotomy

Some authors have recommended simple tenotomy of the flexor tendons with arthrotomy via capsular release to mobilise the PIP joints. This is recommended in flexor tightness leading to hammering of the toe. In leprosy, however, with an anaesthetic sole it can lead to cocking of the toe and increased pressure under the metatarsal head.

Arthrodesis

Where there is longstanding deformity or subluxation, joint damage can occur. This leads to both restriction in the passive or active range of movement in the IP joints of the toe. Secondary joint capsular contracture further impedes the mobility. Where there is significant damage to the articular surfaces, an X-ray is useful, improvement following active tendon transfer is limited. Fusion of both interphalangeal joints to correct plantar flexion is useful in this situation.

Technique

A straight or curved incision is made over the dorsum of the IP joints. The extensor tendon is split longitudinally or retracted to expose the joint capsule. The collateral ligaments are divided and the joint opened. The articular surfaces of the phalanges are removed and the surface opposed with fixation using one or two longitudinal K-wires. Cancellous bone chips

can be inserted from the excised articular surfaces. The extensor tendon is repaired, the skin closed and a plaster applied for six weeks. K-wires are removed between four to six weeks.

Correction of Mallet Toe

For correction of mallet toe, surgical options include:

1) Flexor tenotomy at the DIP joint.
2) Partial or total resection of the middle phalanges.
3) Amputation of the tip of the toe or fusion of the DIP joint.

Correction of Cocked toe/ retracted toe

Where there is marked dorsiflexion of the MTP joints, fusion of the IP joints of the toe worsens the cosmetic deformity and fails to address the primary deformity. This is usually most prominent at the first MTP joint. Fritschi advocates metatarsal head resections through multiple dorsal incisions, to avoid recurrent ulceration over the plantar surface of the metatarsal heads.[13] MTP joint fusion corrects the cosmetic deformity but changes the biomechanics of the forefoot during the push off phase of gait. Where mobility exists at the MTP joints several options are available.

1) Transverse incision dorsally over the crease of the MTP joints with extensor tenotomy and split skin grafting of the skin deficit.
2) A dorsal longitudinal incision over the MTP joints with Z-lengthening of the extensor tendon and capsulotomy.[20]
3) A flexor to extensor transfer (Girdlestone) with division of the extensor tendon just proximal to the MTP joints.
4) Metatarsal head resection with extensor tenotomy or Z- lengthening.

SUMMARY

Successful footdrop correction depends on the contribution of surgeon, physiotherapist and patient. Patients' understanding and motivation is key to a successful outcome particularly after the patient has left the hospital. Regular follow up following surgery reinforces activities learnt. Maintenance of normal gait is important to long term success.

Toe deformities often are a contributing factor to (re) ulceration. Orthotic devices, in addition to surgery, can play an important role in management and prevention of (re) ulceration in the foot that is at risk because of altered biomechanics and impaired sensation.

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