Surgical techniques

Double tendon transfer for correction of drop-foot

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ABSTRACT

Many conditions can cause foot drop, which makes walking difficult because the foot easily bumps into obstacles, or the knee must be kept more flexed than usual during the swing phase of gait, especially when going up stairs. Several techniques that have been described to correct foot drop rely on bone procedures or tendon transfer, with or without bone fixation. In this article, we describe a simple technique that is heavily used in leprosy-endemic countries and provides long-lasting results. It requires a double tendon transfer through the interosseous membrane of leg; the tibialis posterior and flexor digitorum longus are sutured to the tibialis anterior, and extensor hallucis longus and extensor digitorum longus, respectively, proximally to the extensor retinaculum.

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1. Introduction

Several techniques have been described to address paralytic foot drop [1–4]. Although they all correct the foot drop, they are imperfect because of the complexity of the procedure [1] or because they resort to a bone procedure [2,5], which can lead to complications. We propose using Carayon’s technique, which is a simpler procedure being used in developing leprosy-endemic countries. It only requires procedures on tendons and minimally alters their lines of action.

The first tendon transfers were described by Codivilla in 1899 [6]. In 1933, Ober [7] described the transfer of the tibialis posterior onto the anterior tarsus. This technique was repeated in 1957 by Brand and Fritschi [8,9] and also Watkins et al. [10]. However, the bone procedure on the anterior tarsus was the source of failures and poor outcomes. Around the same time, Carayon et al. [11] described suturing the tendon proximally to the ankle. We will describe a variation of this technique, which has been modified over time by surgeons who have extensive experience in leprosy-endemic countries where patients are treated for foot drop secondary to acute, non-resolved peroneal neuropathy or after gluteal injection of malaria drugs [5,12–15].

2. Surgical technique

The patient is placed supine with a cushion under the buttock so that the patella points straight up; it is important to make sure the patella is not tipped medially. The contralateral leg is placed flat on a support under the thigh, with the leg hanging down. The procedure is conducted with a tourniquet to provide preventative hemostasis, without an Esmarch bandage. The patient’s positioning must provide the option to flex the knee during the last stage of the procedure, either by placing a pad or cushion or by having the assistant flex the leg.

The first stage consists of Achilles tendon lengthening, which is mandatory if passive dorsiflexion of 10° cannot be obtained (i.e. 80° if the foot’s normal position corresponds to 90°) when the hip and knee are extended. This is carried out through two small incisions 6–7 cm apart (Fig. 1) according to the technique described by Piriou et al. [16]; the assistant flexes the hip and rotates it externally, then flexes the knee and foot into maximal dorsiflexion. The first incision is a few centimeters above the Achilles tendon insertion and slightly offset medially; once the tendon has been freed up, about half of it can be cut from the medial side; the plantaris tendon is also cut at this point if it is distinct from the Achilles tendon. The second proximal incision in made on the mid-line, while avoiding damaging the sural nerve and the small saphenous vein. The tendon, which is already more slack, is cut laterally through slightly more than half of its width. In both cases, it is important to identify the tendon edges and have a clear view of what is being cut. Lengthening is then performed forcefully in dorsiflexion up to at...
least 80°. The skin incisions are closed one by one in a single layer, without drainage.

For the second stage, the knee is extended and the leg externally rotated. A 5–6 cm incision is made behind the medial malleolus, on the assumed contour of the tibialis posterior tendon, which can be easily palpated between the medial malleolus and the tuberosity of navicular bone. The flexor retinaculum and then the sheath are opened. The tibialis posterior tendon is held with a small dissector and cut distally beyond the medial malleolus with the ankle forced into varus. It is immediately sutured in both planes with a size 2 or 3 braided sutures. It is never handled directly using blunt or serrated forceps. Behind this large tendon and in another sheath that must be opened, the flexor digitorum longus is held and sutured in a similar manner (Fig. 2). These traction sutures are used to place tension on the two tendons. Long, curved Metzenbaum scissors are introduced under the crural fascia proximally and then used to cut it subcutaneously as far away as possible over about 10 cm; this makes it easier to recover the distal ends by the anterior incision. The tendons are wrapped in moist gauze dressing to prevent desiccation.

The next incision is made over the anterior compartment about 1 cm lateral to the tibial crest; the leg rotation is unimportant here. This incision is 10–12 cm long and proximal to the upper edge of the superior extensor retinaculum, which must remain intact to prevent the transferred tendons from bowing. The crural fascia is partially resected over the entire length of the incision and about 1 cm of its width. The limit between the crural fascia and the superior extensor retinaculum will be clearly visible. The transferred tendons will be sutured proximally to this retinaculum. Experience has shown that tendon fixation distally on the capsule or by an intra-osseous route is difficult to carry out. In addition, the transferred tendons have a tendency to get stuck in narrow passages or canals. One important rule of tendon transfers is that the transfer must be as direct as possible and should not pass through any narrow areas [17].

With the foot in 80° dorsiflexion, the tibialis anterior tendon and extensor digitorum longus tendon, which is often split into two tendons at this level, are circumferentially released from their synovial sheath. With the foot held in maximum dorsiflexion, the three tendons are split longitudinally over 10–12 mm up to the proximal part of the retinaculum. A reverse loop stitch must be applied to prevent propagation of the tendon division proximally; the free ends of the suture knot must be buried (Fig. 3).

The muscles of the anterior compartment and the anterior tibial vascular bundle are reflected with deep Farabeuf retractors until the interosseous membrane is released over the entire length of the incision; one or two thin Hohmann-Muller spike retractors can be placed against the fibula to provide better exposure of the interosseous membrane (Fig. 4). The membrane is completely excised between the tibia and fibula with a No. 3 long-handle scalpel. The priority is to remove the membrane proximally as opposed to distally, where the space is very narrow. At the upper end of the incision, the membrane must be completely removed; if needed, Metzenbaum scissors can be used to open it further proximal in a blinded manner.

The two tendons being transferred must be moved to a different compartment, either by recovering them in the intertibiofibular space or by grasping the two traction sutures by sliding Bengolea

**Fig. 1.** Two posterior incisions made to lengthen the Achilles tendon.

**Fig. 2.** Harvesting of the two tendons for transfer.

**Fig. 3.** Loop stitch placed on the divided tendons.
forceps into the interosseous space behind the tibia until it exits against the medial malleolus (Fig. 5). This latter maneuver is dangerous. One must be careful not to pinch the posterior tibial neurovascular bundle, because it will be impossible to pull the tendons into the anterior incision. By pulling on the two sutures, it is possible to pull the tendons and their myotendinous junction up into the interosseous space and above the level of the incision (Fig. 6). It is often necessary to trim the myotendinous junction a bit at this point. The medial incision is closed, typically without a drain.

The free end of the tibialis posterior is moved from deep to superficial through the opening made in the tibial anterior. The same technique is used to pass the flexor digitorum longus through the two extensor tendons. The assistant holds the knee in slight flexion and the foot in dorsiflexion. The transferred tendon is sutured to itself under good tension by placing two or three reverse stitches on each side with resorbable suture (Fig. 7).

A drain is not compulsory as there is little room for it. The surgeon places a plaster or resin circular below-knee cast with the ankle in 80° dorsiflexion; the cast is immediately split open anteriorly. Immobilization is required for 4 weeks. The patient can get around without weight bearing by using canes or by using an unloading boot, if a very short, well-fitting boot was initially made.

After the fourth week, the resin cast halves are opened to evaluate healing; non-loaded rehabilitation is initiated and the patient continues to wear the posterior half of the cast for about ten days when not participating in rehabilitation sessions. Full weight bearing is allowed after six weeks. We have not personally used early active motion as described by others [15,16], mainly because those studies related to isolated Achilles tendon lengthening, not tendon transfer.
3. Discussion

This is a simple technique that can be learned quickly by a surgeon. The lines of action of the transferred tendons are direct. The tibial anterior is left in place, thereby avoiding incisions over the foot as described by Tomeno et al. [1]. Their technique is more complex because the tibialis anterior tendon is detached down to its insertion and rerouted through the bones of the foot, which provides it with a better line of action. The double tendon transfer technique described here acts as reins on a horse to stabilize the foot’s inversion/eversion, without any varus during walking, even during the swing phase [13]. Other surgical foot drop correction techniques require bone fixation of the transferred tendon [2] and additional fusion [5], which can lead to complications, lack of fixation and wound dehiscence. Moreover, terminal bone fixation of the transferred tendon does not allow the surgeon to set the muscle tension, which can have repercussions on the movement amplitude in the future because of the active nature of the transfer. The Pulvertaft suture technique has the same shortcomings [1,2]. Still other techniques use a circumtibial transfer route [3,12], which can lead to residual foot varus if the posterior tibialis only is transferred.

The main indications for this transfer are drop-foot secondary to high or low post-traumatic paralysis of the sciatic nerve due to sequelae of disc herniation or compartment syndrome. The model patient is one with intact sensory innervation and good sensation in the sole of the foot. But in cases of complete nerve damage, this technique is still relevant if trophic disorders are prevented using appropriate insoles, self-monitoring and daily hygiene. It can also be used in cases of complete paralysis if the sole goal is a tenodesis effect.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References