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Reactivation of the Dorsiflexors of the Foot in Leprotic Paralysis of the Common Peroneal Nerve

Observations on 26 Cases¹A. Carayon, P. Bourrel and M. Bourges²

Paralysis of the common peroneal nerve is a fairly common occurrence in leprosy; it is shown by foot drop similar to that seen in traumatic paralyzes, the treatment of which has posed the same problems that have been solved by three types of surgical operation, viz., (1) modified arthrodesis of Lambrinudi-Boppe (^{19, 20}), (2) transfer of the posterior tibial tendon to the tarsus, and (3) reactivation of the dorsiflexors of the foot.

The operation of Lambrinudi-Boppe has been performed by many workers, among them ourselves, right from the beginning of what may be called the surgical era of leprosy. For several years this has been the

operation of choice in paralyzes of the common peroneal nerve, but its disadvantages are now well recognized. Actual study of the results of operation made by Meary (²⁰) with respect to 48 cases, by MacKenzie (¹⁹) with respect to 100, and by Clawson and Seddon (¹³) with respect to 329, reveals a high proportion of failures, such as recurrence of the drop foot, yielding of the external tibio-astragaloid ligaments, and joint damage. To these sequelae, there is added in the case of leprosy the presence of trophic effects due to co-existing damage to the nerves of the foot, which, in several of our observations, has been the cause of inadequate bone fusion, delayed skin healing, and chronic draining sinuses. These considerations have led to abandonment of this procedure by most authors in favor of tendon transfer.

Transfer of the tendon of the tibialis posterior, suggested for leprosy by Fritsch

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and Brand⁽¹⁵⁾ and then by Gunn and Molesworth⁽¹⁶⁾, is generally carried out by the interosseous route, as suggested by Watkins and associates⁽²⁴⁾ rather than by the circumtibial route of Ober. One of us (P.B.) has performed this operation six times, but besides the difficulty of selecting the exact point for the bony implantation, so as to avoid medial or lateral deviation of the foot, in two of our cases the trophic condition of the bones was the cause of loosening of the intraosseous suture (Fig. 1), a result seen also by Ross and MacLean⁽²¹⁾. Furthermore, this operation, like that of Lambrinudi, ignores the fate of the toes and is contraindicated where there are trophic abnormalities in the bones of the posterior portion of the tarsus, as recalled by Sanchez-Beaujon⁽²²⁾, who, it may be noted, performs this transfer by resecting the fibula subperiosteally for 3 or 4 cm. so as to increase the range of movement.

From 1953 on, one of us (A.C.)⁽¹¹⁾ has performed a tendon reactivation similar to those in use in the upper limb in the case of radial paralysis. After being passed through the interosseous membrane, the tendon of the tibialis posterior muscle is joined to that of the tibialis anterior, and the tendon of the flexor digitorum longus

is joined to the extensor hallucis longus and to the extensor digitorum longus tendons. The nerve damage in the lower limb seen in leprosy picks out the trunk of the common peroneal nerve, while the posterior tibial nerve is unaffected; this allows the use of the muscles innervated by the latter nerve as reactivators.

We published the first results of our experience^(8, 9, 10), and the good results obtained by this method allow us now to suggest it as the routine treatment in all cases of nerve-trunk paralysis of the common peroneal nerve in leprosy. It thus would seem useful, in our eyes, and in the light of experience in 26 cases, to recount the exact technic and the indications for the operation.

TECHNIC

(Illustrated in Fig. 2)

The operation is performed with a pneumatic tourniquet applied to the thigh. A vertical incision 8 cm. long is made 2 cm. behind the posterior medial border of the tibia in the lower third of the leg, ending at the level of the tip of the medial malleolus. The tendons of the tibialis posterior and flexor digitorum longus muscles are exposed and divided at the lowest possible level, while the foot is maintained in dorsal

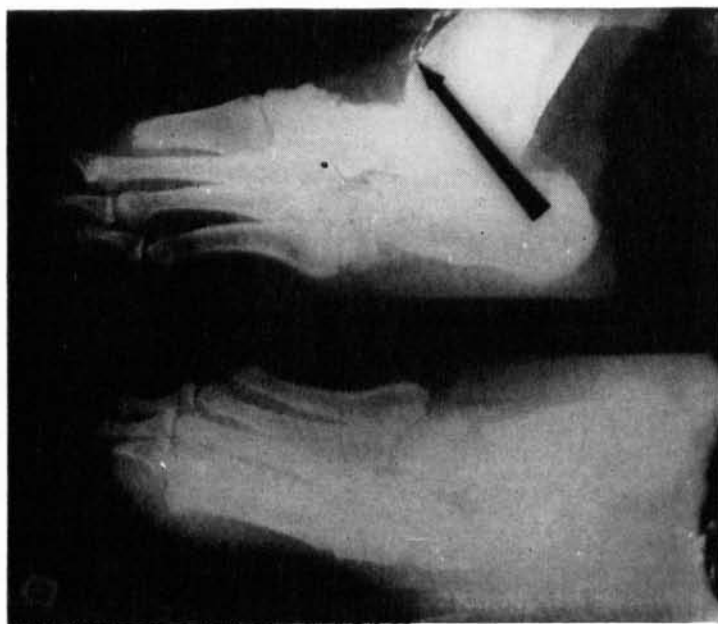


FIG. 1. Secondary loosening of the interosseous suture in a Watkin's operation.³

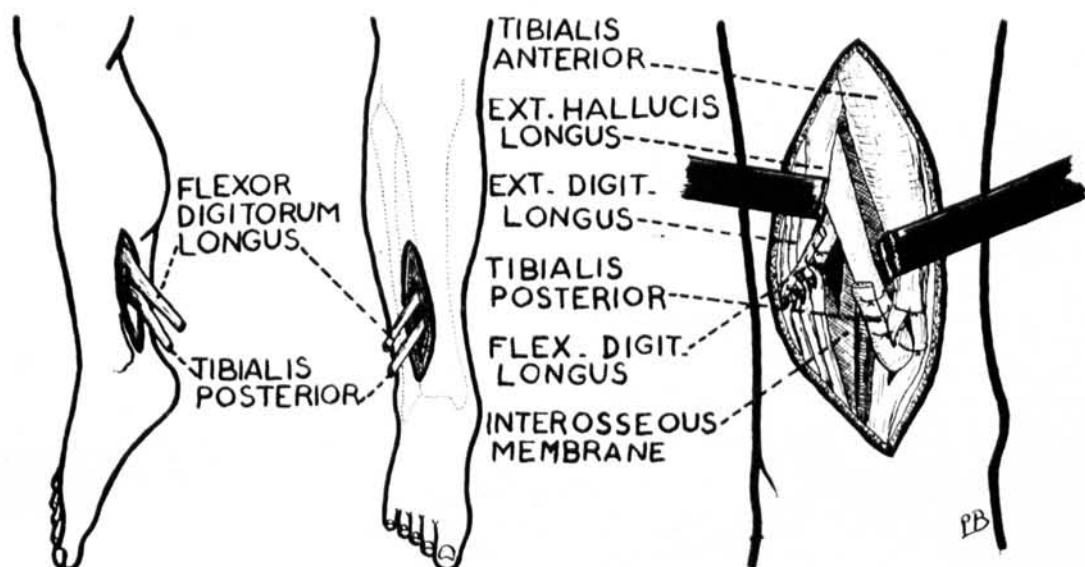


FIG. 2. Technic of the Carayon operation.³

flexion and medial rotation. A second incision, 8 to 10 cm. long is made 2 cm. lateral to the anterior tibial crest, commencing at the level of the base of the lateral malleolus and extending proximally. The interval between the tibialis anterior and extensor hallucis longus is developed down to the interosseous membrane, which is identified and excised as far proximally as possible.

Through the interosseous membrane the end of a curved forceps is directed along the posterior surface of the tibia. It appears finally in the posterior medial incision and grasps the ends of the flexor digitorum longus and tibialis posterior. These tendons are brought into the anterior compartment of the leg. Sometimes the fleshy body of one or both of these muscles extends so far distally that the muscle mass is too bulky to permit the easy gliding necessary for good function. Some of the more distal muscle fibers must be trimmed away to make sure that only tendons cross the interosseous space. The tibialis posterior is

sutured to the tibialis anterior and the flexor digitorum longus is fixed to both the extensor digitorum longus and the extensor hallucis longus.

The attachment is of the "loop type," i.e., the transferred tendon transfixes the paralyzed tendon and loops back to be sutured side-to-side with itself. Progressive upward splitting of the paralyzed tendons, resulting in a slack of the montage, is prevented by an arresting stitch.

The transferred tendons should be attached as low as possible to allow the tendons to pull in a straight line. Tendon suture should be performed with maximum dorsiflexion of the foot and extension of the toes. When necessary, lengthening of the Achilles tendon should be performed prior to tendon suture. Debridement of the calcaneal canal and neurolysis of the plantar nerves can also be performed.

A below-knee cast is applied with the toes and the foot maintained in dorsiflexion. Immobilization is discontinued after fifteen days.

RESULTS

This surgical procedure was carried out 18 times with the technic described.

After the plaster cast is removed (15th day) the foot drop is overcome and the

³These figures have been published previously (9). Permission for republication has been given by the *Annales de Chirurgie*. Fig. 1 = Fig. 7, p. 1516; Fig. 2 = Fig. 10b, p. 1518; Fig. 3 = Fig. 8, p. 1517.

foot in repose rests at an angle of 90° with the axis of the leg. Active extension of the foot is possible up to 120° . Active dorsiflexion of the foot and extension of the toes are at first tried lightly for two or three weeks, and then attain an amplitude of about 15° . Utilization of the muscle reactivators which previously had an antagonistic action, requires reeducation. After eight to 10 days of supervised exercises, this reeducation will continue spontaneously. It will be necessary to wait for three or four months, however, before active movements of great amplitude, i.e., on the order of 40° , are achieved (Fig. 3).

Fully automatic walking reappears only six months after reeducation. It takes several weeks for the patient to get rid of compensatory movements acquired prior to surgery, such as lifting and flexing the knee to step forward. This is proof that non-physiologic automation can be present. The

braking effect during the first half of the step is reestablished in part. Walking on the heels is rarely attained.

We have been able to carry out electromyographic study and measurement of strength on one of our operated patients. A normal electromyographic pattern is noted for the tibialis posterior muscle when the patient's foot is in dorsiflexion, but a very large number of motor units are involved, as though the muscle were mobilizing as many resources as possible to accomplish the most important efforts. Ergometric study revealed that dorsiflexion will have recovered 66 per cent of its total potentiality, as determined by comparison with the healthy side. However, as respects duration, dorsiflexal activity is deficient by 52 per cent, and the activity of each individual motion by 72 per cent. This seems to be due to a decrease in the angle of dorsiflexion. These results of the electric

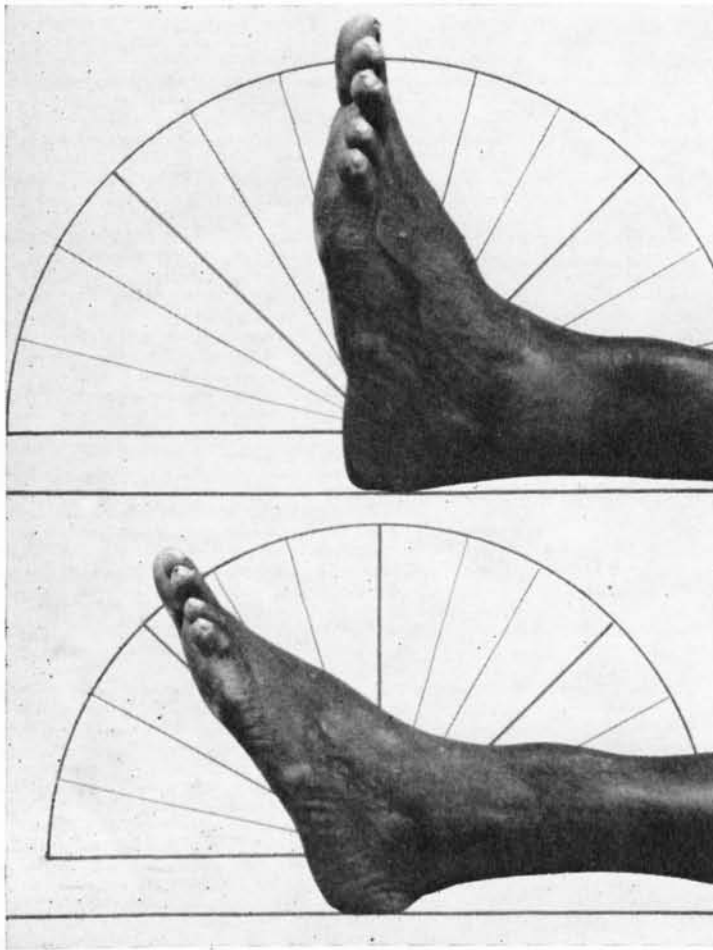


FIG. 3. Good result of a Carayon operation.³

and ergometric tests were expected, and are indeed confirmation of Fick's findings.

Total evaluation of results. Seven results were excellent. The amplitude of dorsiflexion and plantar flexion of the foot is equal to or greater than 40° (20° in each direction from a right angle). In one case walking on the heels was possible.

Five results were good. The amplitude of dorsiflexion and plantar flexion was less than 30° , and, particularly in one case, where the transplantation completed the operation of Lambrinudi initially performed.

Two results were fair. The effect resulted from tenodesis only, without active dorsiflexion, the foot being maintained at 95° in leprosy patients.

Three results were poor. Dorsiflexion required intense efforts, and the foot at rest lay extended at an angle of 115° in uncooperative leprosy patients who refused a repeat operation to shorten the dorsal tendons and maintain the foot at an angle of 90° .

In one case the immediate result was very good, but it was followed by fracture of the neck of the astragalus. The strong pull of the transferred tendons caused the weakened bone to fracture. Subtalar and midtarsal arthrodesis had to be carried out.

CRITICAL REVIEW OF THE OPERATIVE PROCEDURE

Objection to the procedure could be raised on the ground that it endangers the anterior tibial neurovascular bundle. This has not been an obstacle in any of our cases; no such damage has occurred. Actually, if damage did occur, it would be inconsequential, since it would involve a paralyzed nerve and an artery serving chiefly an area above the zone of the operation.

There are two disadvantages in the procedure. (1) Usually only the flexor hallucis longus is very fleshy in the lower third of the leg. However, in heavily muscled men the tibialis posterior muscle and the flexor digitorum longus are often bulky. This requires stripping of the lower muscular

fibers, and an extensive excision of the interosseous membrane.

(2) The intrusion of two tendons and their reactivating loop in the narrow anterior space of the leg does not permit suture of the deep fascia of the leg. A slight hernia of the tendons persists, which is the "hallmark" of the operation.

It is this which has led one of us (M.B.) to modify to some extent, the initial procedure of tendon transfer in eight cases, using an anterior incision commencing in the lower third of the leg and terminating at the level of insertion of the tibialis anterior muscle. The interosseous membrane is not excised, but simply incised for 4 cm., and the motor tendons are sutured side-to-side to the paralyzed tendons, the suture being carried several centimeters downward to a level below the tibio-tarsal interspace. This procedure permits suture of the aponeurosis of the leg and prevents a muscular hernia.

The results were good in four cases and fair in two; extension of the toes was possible, but dorsiflexion of the foot was defective. In two cases dorsiflexion could not take place, but the foot rested at an angle of 90° (tenodesis effect). In addition significant postoperative edema was observed in six cases.

It appears, therefore, that the failure to remove the interosseous membrane permitted the tendons to adhere to the interosseous membrane, and that the closure of the deep fascia has been the cause of venous compression that resulted in postoperative edema.

Finally the side-to-side anastomosis cannot be performed with a tension as great as in the loop procedure.

Brand⁴ regards the toes as protectors of the metatarsal heads and questions if it is good to remove the flexor digitorum longus and use it as a dorsiflexor. He suggests attaching the distal stump of the tendon side by side to the flexor hallucis longus, so that the contraction of that muscle will flex all the toes. Actually, in our series no trophic ulcerations developed at the level of the metatarsal heads, but we shall certainly try to activate the distal part of the flexor digitorum longus in the next suitable case.

The proposed operation offers many advantages:

⁴ Personal communication.

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The proposed operation offers many advantages:

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(a) Prevention of trophic disturbances, by elimination of every operative maneuver on the foot and above all on the tarsus. The whole procedure is carried out above the instep, remote from eventual trophic changes.

(b) Simplicity of reactivation by the loop procedure, as compared with the difficulties of transosseous fixation.

(c) Avoidance of varus deviation of the foot. This is the result both of suppression of the tibialis posterior muscle, i.e., the muscle leading to varus, and reactivation of the extensor digitorum longus, the muscle effecting valgus.

(d) Restoration of a nearly normal status of the foot permitting its active dorsiflexion, as in the Watkins operation (²⁴), but with greater extension of the toes, which will be the first step in the motion of dorsiflexion. This correction of the clawing of the toes, which it brings about, is another advantage over the operation of Lambrinudi and that of Watkins. It would appear that numerous authors who followed the Watkins procedure have now modified their technic. Brand and Selvapandian (⁵), for example, now combine the transplantation of the tibialis posterior with a tenodesis of the extensors of the toes in order to avoid their dragging on the ground during walking. In our opinion reactivation of the extensors of the toes is a better procedure.

Clawson and Seddon (¹³), after utilizing the transfer of the tibialis posterior to the tarsus in the treatment of drop foot of non-leprotic origin, seem to have inclined later toward reactivation of the extensor of the toes by this same muscle, the tibialis posterior.

Andersen (^{1,2}) proposed fixation of the tendon of the tibialis posterior either to the tendon of the tibialis anterior and to the peroneus longus, transposed to the anterior surface, or to the extensor hallucis longus and extensor digitorum longus, with the aim precisely of treating clawing of the toes, a deformity he found in 38 of his patients.

(e) A short period of immobilization (reduced to two weeks in place of six, with respect to tendon-to-bone transfer, and in place of three to four months with respect to arthrodesis).

(f) Compliance with Sherb's rule (²³): since all the dorsiflexors, i.e., antagonists of the transplanted muscles, are paralyzed, the transplanted muscles will work well.

Since transfer of the tibialis posterior tendon alone has given good results in the hands of Watkins *et al.* (²⁴), Fritschi and Brand (¹⁵), Gunn and Molesworth (¹⁶), Clawson and Seddon (¹³), Asvazadurian and Gambier (³), Lipscomb and Sanchez (¹⁸), and Darcy (¹⁴), transfer of the two tendons should be even more satisfactory. The fracture of the neck of the talus that occurred in one patient under the action of the dorsiflexors is a proof of this. Only in the case of failure could we see the need for arthrodesis, as recommended by Brand (⁴), provided that the trophic state of the foot allowed it. However, even if the result of reactivation is functionally only moderate and does not permit active dorsiflexion, there remains the effect of the tenodesis; once the pronating action of the tibialis anterior and the supinating action of both tibialis anterior and extensor hallucis longus have been suppressed, arthrodesis becomes unnecessary.

PREREQUISITES FOR REACTIVATION OF THE DORSIFLEXORS OF THE FOOT

It is essential that the muscles of the posterior compartment of the leg have retained their normal nerve supply, so that the muscles to be transferred are active and the remaining muscles are able to extend the foot.

It is equally necessary to ascertain pre-operatively that the range of passive dorsiflexion is adequate. When this is limited, in spite of pre-operative splinting and physiotherapy, it is necessary to perform beforehand, or at the same time as the operation, a tendon lengthening of the Achilles tendon, eventually completed by posterior capsulotomy.

Indications. At the present time, and in view of the relatively small number of our observations, we consider that there are two groups of indications:

Absolute indications.—All paralyzes of the common peroneal nerve associated with trophic disturbances of the foot (which is often the case in leprosy and indicate additional neurolysis of the plantar nerves below the medial malleolus).

Optional indications.—Traumatic paralyzes of the trunk of the common peroneal nerve and leprotic paralysis of the nerve where there are no trophic disturbances of the foot. Only after study of a larger number of observations drawn from other surgeons, will it be possible to conclude that this procedure should be undertaken routinely in all paralyzes of the common peroneal nerve where the muscles of the posterior compartment of the leg remain undamaged.

SUMMARY

The results of reactivation of the dorsiflexors of the foot by two muscles from the posterior compartment of the leg (the tibialis anterior by the tibialis posterior; and the extensor hallucis longus and the extensor digitorum longus by the flexor digitorum longus), tend to demonstrate that this operation is to be preferred to (1) the operation of Lambrinudi, which often meets with delayed healing of bone and soft parts and septic complications, and requires a long period of immobilization, (2) transfer of the tibialis posterior muscle to the tarsus, which often results in non-union due to leprosy dystrophy of the bone.

The reactivation of the dorsiflexors of the foot by the tendons of the tibialis posterior muscle and flexor digitorum longus (26 cases) is performed in the leg, at some distance from the site of trophic disturbances, by a surgical technic that is at once simple and lasting. The period of immobilization is short (16 days), and complications are encountered very rarely.

RESUMEN

Los resultados de la reactivación de los dorsiflexores del pie por dos músculos del compartimento posterior de la pierna (el tibialis

anterior por el tibialis posterior; y el extensor hallucis longus y el extensor digitorum longus por el flexor digitorum longus) muestran que esta operación es superior a (1) la operación de Lambrinudi, la cual es frecuentemente seguida de una falla de la curación normal, por complicaciones sépticas y por falta de unión de los huesos a causa de alteraciones tróficas y requiere un largo período de inmovilización y (2) trasplantes aislados del tendón tibialis posterior al tarsus, los cuales frecuentemente resultan en falta de unión como resultado de trastornos tróficos en el hueso.

La reactivación de los dorsiflexores del pie por los tendones del tibialis posterior, y del flexor digitorum longus (26 observaciones) es realizada en la pierna, a alguna distancia del sitio de las alteraciones tróficas, por una técnica quirúrgica que es la vez simple y duradera. La duración del tiempo de inmovilización es corto (16 días), y raramente se encuentran complicaciones.

RÉSUMÉ

On a étudié la réactivation des muscles fléchisseurs du dos du pied par deux muscles de la loge postérieure de la jambe: le tibial antérieur (tibialis anterior) par le tibial postérieur (tibialis posterior), et l'extenseur du gros orteil (extensor hallucis longus) ainsi que l'extenseur commun (extensor digitorum longus), par le fléchisseur commun (flexor digitorum longus). Les résultats semblent démontrer: (1) d'une part, que cette opération doit être préférée à l'opération de Lambrinudi, car celle-ci est souvent suivie d'une cicatrisation tardive de l'os et des parties molles, et de plus entraîne une longue période d'immobilisation; (2) d'autre part aux transplantations du muscle tibial postérieur (tibialis posterior) au tarse, qui entraînent souvent une absence de réunion des fragments comme conséquence des troubles trophiques au niveau de l'os.

Dans cette étude, qui porte sur 26 observations, la réactivation des muscles fléchisseurs du dos du pied par les tendons du tibial postérieur (tibialis posterior) et du fléchisseur commun des orteils (flexor digitorum longus) est pratiquée au niveau de la jambe, à une certaine distance des troubles trophiques. Pour ce faire, on utilise une technique chirurgicale qui est à la fois simple et donne lieu à des résultats durables. La période d'immobilisation est courte: 16 jours. Les complications sont fort rares.

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