AMERICAN ORTHOPAEDIC FOOT & ANKLE SOCIETY

Foot & Ankle International®
2016, Vol. 37(6) 665–669

DOI: 10.1177/1071100716629779
fai.sagepub.com

Triple Tendon Transfer for Correction of Foot Deformity in Common Peroneal Nerve Palsy

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Abstract

Background: Anterior transfer of posterior tibial tendon (PTT) is the most common technique to correct foot drop in patients with common peroneal nerve palsy. It does not address the loss of toe extension or "toe drop." This may affect the gait pattern, and patients may not tolerate it. Described here is a technique that addresses toe drop associated with common peroneal nerve palsy.

Method: A new technique of tendon transfer using the PTT, flexor hallucis longus (FHL) tendon, and flexor digitorum longus (FDL) tendon was performed on 15 patients (13 males and 2 females) with complete common peroneal nerve palsy from 2009 to 2013. Minimum follow-up was 12 months (range, 12-50 months). The mean age was 37 years (range, 20-52 years).

Results: Based on the evaluation criteria of Carayon et al, the postoperative results for foot drop correction were excellent in 9 (60%), good in 5 (33%), and moderate in 1 (7%), and the mean active range of motion of the ankle was 46 degrees. Postoperative extension evaluation of the toes was excellent in 7 (47%), good in 5 (33%), and moderate in 3 (20%).

Conclusion: Releasing and transferring of FDL and FHL to the toe extensors along with the anterior transfer of the PTT neutralized the deforming forces and allowed for active toe extension while strengthening ankle dorsiflexion. Movahedi Tendon Transfer was a reliable method to achieve a balanced foot and toe dorsiflexion for complete common peroneal nerve palsy.

Level of Evidence: Level IV, retrospective case series.

Keywords: tendon disorders, neuromuscular disorders, gait studies, peroneal nerve palsy, tendon transfer, foot drop

Introduction

The common peroneal nerve consists of 2 divisions. The superficial peroneal nerve innervates the peroneus longus and peroneus brevis tendons; these tendons evert the foot. The deep peroneal nerve innervates the tibialis anterior, extensor digitorum longus (EDL), and extensor hallucis longus (EHL) tendons; these tendons dorsiflex the foot, and extend the toes. Ischemia, mechanical irritation, traction, crush injury, and laceration can cause injury to the peroneal nerve. If the common peroneal nerve is damaged, the patient may lose the ability to dorsiflex and evert the foot resulting in foot drop and the ability to extend the toes or "toe drop." Anterior transposition of the posterior tibial tendon (PTT) to the dorsum of the foot was described by Ober in 1933 that did this transfer through the circumtibial route and inserted it into the third metatarsal bone.[6] Watkins et al reported the same transfer through the interosseous membrane in 1954.[10] Anterior transposition of the PTT to the dorsum of the foot has been widely used and has become the most accepted reconstructive method to correct drop foot; however, it is difficult to achieve balanced dorsiflexion.

There are also patients who have foot drop with toe drop. Conventional PTT transfer does not address the loss of toes extension, although toe flexion contracture may not be evident with the ankle plantarflexed; once the deformity is corrected, the toe contracture may become obvious, which may affect the gait pattern and patients may not tolerate it. Sacrificing the long flexor tendons at the interphalangeal joints has been the solution for this problem in the past but patients often were not satisfied because they had no control of their toes. Rodriguez introduced the Bridle procedure

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Table 1. The Evaluation Criteria of Carayon et al.

	Excellent	Good	Moderate	Poor
Active dorsiflexion	>15 degrees	5-15 degrees	No active dorsiflexion	Presence of plantar flexion that prevent ankle motion
Active plantar flexion	>30 degrees	15-20 degrees	Drop foot totally corrected	
Active ROM	>40 degrees	20-30 degrees	Plantar flexion is possible up to 10 degrees	

Abbreviation: ROM, range of motion.

Table 2. The Evaluation of the Toe Extension.

	Excellent	Good	Moderate	Poor
Active extension of MTPJ and IPJ	Active extension of MTPJ and IPJ from neutral	Active extension of MTPJ from neutral	No active extension but no toe drop	No active extension with toe drop

Abbreviations: IPJ, interphalangeal joint; MTPJ, metatarsophalangeal joint.

"Stirrup-plasty" with anterior transfer of the PTT and a dual anastomosis to the tendon of the anterior tibial and a rerouted peroneus longus.[8] Ozkan et al introduced a split tendon transfer of the PTT to the dorsum of the foot, where it was split into 2 parts. One strip was attached to the tibialis anterior tendon and the other to the EHL, EDL, and peroneus tertius tendons.[7] Vigasio et al introduced a double tendon transfer where the PTT was transferred to the tibialis anterior and the flexor digitorum longus (FDL) was transferred to the EDL and EHL tendons.[9] Transfer of a tendon to another tendon and not to the bone to restore the ankle dorsiflexion or transfer of a tendon to several tendons may diminish the function and power of the transferred tendon as well as the balance of the dorsiflexion.[5]

In this article, a new technique of triple tendon transfer with PTT, FDL, and flexor hallucis longus (FHL) tendons transposed anteriorly through the interosseous membrane is described. The PTT was transposed subcutaneously to the dorsum of the foot and anchored to the middle cuneiform whereas the FDL and FHL tendons were transposed through the superior extensor retinaculum to the dorsum of the foot; the FDL was sutured to the EDL and FHL sutured to the EHL tendons. The goal of this study was to evaluate this novel technique.

Method

The study included 15 patients (13 males and 2 females) with a mean age of 37 years with complete common peroneal nerve palsy, who underwent a new technique of tendon transfer from 2009 to 2013. Minimum follow-up was 12 months (range, 12-50 months). All patients received conservative treatment with ankle foot orthoses and serial electromyography and nerve conduction velocity assessment to prove complete lesion of the common peroneal nerve with no improvement. Twelve patients had common peroneal nerve injury because of motor vehicle accident and 3 patients had iatrogenic injury. The mean duration of symptoms prior to surgery was 1 year. Normal function and strength of gastrocsoleus, PTT, FDL, and FHL were also assessed with electromyography and nerve conduction velocity studies. Preoperative ankle evaluation was based on the evaluation criteria of Carayon et al (Table1).[1] Because the criteria were for evaluation of the ankle and foot drop correction, toe extension evaluation criteria (Table 2) were added to it to evaluate the toe drop correction.

The operation was done with general anesthesia or spinal anesthesia with the patient positioned supine and a pneumatic tourniquet was applied to the thigh. The first incision was made medially from the talonavicular joint to the first tarsometatarsal joint (Figure 1) to harvest the PTT from the navicular and to release the FHL and FDL tendons at the knot of Henry. The second incision was made medially along the calf and 15 cm above the ankle (Figure 1). The tibialis posterior and FDL tendons were identified by moving their distal stump and they were pulled proximally.

The third incision was made anterolaterally and slightly distal to the second incision (Figure 1), and a wide window about 5 to 8 cm was opened in the interosseous membrane. A large, curved clamp was then passed through the interosseous window to pull all 3 tendons from medial to lateral at a 45 degree angle. The fourth incision was made over the dorsum of the midfoot (Figure 1) and a long curved clamp passed subcutaneously from this incision to the third incision so the PTT could be transposed subcutaneously to the dorsum of foot. Again with the same clamp passed along the course of the EDL and EHL tendons through the superior extensor retinaculum from this

Figure 1. The first incision was made to harvest the posterior tibial tendon (PTT), flexor hallucis longus (FHL), and flexor digitorum longus (FDL) tendons. The second incision was made to pull them proximally. The third incision was made to pull all 3 tendons from medial to lateral. The fourth incision was made to transfer PTT subcutaneously as well as FDL and FHL tendons through the superior extensor retinaculum (SER) to the dorsum of the foot.

incision to the third incision, the FDL and FHL tendons were transposed through the superior extensor retinaculum to the dorsum of the foot. If necessary, debridement of tibialis anterior tendon could be performed to have enough room for the FHL and FDL tendons in the anterior tarsal tunnel. The middle cuneiform was prepared and a tunnel made with a 7.0-mm drill, and a 3.0-mm suture anchor was inserted into the bone on the side of the tunnel. The PTT was transferred through the tunnel in the middle cuneiform; next, while the ankle was held in 10 degrees of dorsiflexion, the suture attached to the anchor was used to secure the tendon into the tunnel. It is also possible to use an interference screw instead of the suture anchor to secure the transferred tendon. If necessary, a percutaneous Achilles tendon lengthening as described by Moreau and Lake[2,4] should be performed to achieve passive dorsiflexion. While the ankle was held in dorsiflexion and the metatarsophalangeal and interphalangeal joints of the toes held in extension, the FHL was sutured to the EHL and FDL sutured to the EDL tendons with nonabsorbable nylon and side-to-side suture technique. A well- padded nonweightbearing short leg cast was applied in maximum ankle dorsiflexion with the toes in extension. The nonweightbearing short leg cast was changed to air cast or foot walker after 6 to 8 weeks and the patient was permitted to partial weightbearing for another 4 to 6 weeks.

Postoperative Physiotherapy Protocol

Physiotherapy started 6 to 8 weeks after surgery every other day, which consisted of 15 sessions where the first 5 sessions comprised the period of gentle active assisted range of motion. In the second 5 sessions, active range of motion against gravity was emphasized. For the last 5 sessions, the patient wore a boot and started standing and walking. Full weightbearing without any support was allowed only after 12 weeks.

Results

Preoperative and postoperative evaluations of foot drop and toe drop are shown in Tables 3, 4, and 5. Mean postoperative active dorsiflexion was 14.6 degrees. Mean postoperative active plantarflexion was 30 degrees. The mean postoperative active range of motion was 46 degrees. Based on the evaluation criteria of Carayon et al, the postoperative result for foot drop correction was excellent in 9 (60%), good in 5 (33%), and moderate in 1 (7%).

Table 3. Preoperative and Postoperative Foot Drop.

Preoperative					Postoperative				
Case	Active DF	Active PF	Active ROM	Score	Case	Active DF (degrees)	Active PF (degrees)	Active ROM (degrees)	Score
1	Presence of plantarflexion with no active dorsiflexion that prevents ankle motion			Poor	1	>15	>30	>40	Excellent
2				Poor	2	No	Foot drop corrected	10 (plantarflexion)	Moderate
3				Poor	3	>15	>30	>40	Excellent
4				Poor	4	>15	>30	>40	Excellent
5				Poor	5	5-15	15-20	20-30	Good
6				Poor	6	>15	>30	>40	Excellent
7				Poor	7	>15	>30	>40	Excellent
8				Poor	8	5-15	15-20	20-30	Good
9				Poor	9	>15	>30	>40	Excellent
10				Poor	10	>15	>30	>40	Excellent
11				Poor	11	5-15	15-20	20-30	Good
12				Poor	12	5-15	15-20	20-30	Good
13				Poor	13	>15	>30	>40	Excellent
14				Poor	14	>15	>30	>40	Excellent
15				Poor	15	5-15	15-20	20-30	Good

Abbreviations: DF, dorsiflexion; PF, plantarflexion; ROM, range of motion.

Table 4. Preoperative and Postoperative Toe Drop.

Preoperative			Postoperative		
Case	Active extension of MTPJ and IPJ	Score	Case	Active extension of MTPJ and IPJ	Score
1	Toe drop with no active extension	Poor	1	Active extension of MTPJ and IPJ from neutral position	Excellent
2		Poor	2	No active extension but no toe drop	Moderate
3		Poor	3	Active extension of MTPJ and IPJ from neutral position	Excellent
4		Poor	4	Active extension of MTPJ from neutral position	Good
5		Poor	5	No active extension but no toe drop	Moderate
6		Poor	6	Active extension of MTPJ and IPJ from neutral position	Excellent
7		Poor	7	Active extension of MTPJ and IPJ from neutral position	Excellent
8		Poor	8	No active extension but no toe drop	Moderate
9		Poor	9	Active extension of MTPJ and IPJ from neutral position	Excellent
10		Poor	10	Active extension of MTPJ and IPJ from neutral position	Excellent
11		Poor	11	Active extension of MTPJ from neutral position	Good
12		Poor	12	Active extension of MTPJ from neutral position	Good
13		Poor	13	Active extension of MTPJ from neutral position	Good
14		Poor	14	Active extension of MTPJ and IPJ from neutral position	Excellent
15		Poor	15	Active extension of MTPJ from neutral position	Good

Abbreviations: IPJ, interphalangeal joint; MTPJ, metatarsophalangeal joint.

Postoperative extension evaluation of the toes was excellent in 7 (47%), good in 5 (33%), and moderate in 3 (20%). One of the cases developed anterior tarsal tunnel syndrome that improved after physiotherapy and refused the anterior tarsal tunnel release.

Discussion and Conclusion

Movahedi Tendon Transfer was designed to correct the foot and toe drop deformity in complete common peroneal nerve palsy. Conventional anterior transfer of the PTT can

Table 5. Postoperative Foot and Toe Drop Evaluation.

Case	Sex	Age (y)	Ankle DF (degrees)	Ankle PF (degrees)	Ankle ROM (degrees)	MTPJ extension	IPJ Extension
1	M	28	20	40	60	Extension of MTPJ from neutral	Extension of IPJ from neutral
2	M	52	No	10	10	No extension but no toe drop	No extension but no toe drop
3	M	20	20	35	55	Extension of MTPJ from neutral	Extension of IPJ from neutral
4	F	22	20	35	55	Extension of MTPJ from neutral	Extension of IPJ from neutral
5	M	46	10	20	30	No extension but no toe drop	No extension but no toe drop
6	F	38	20	35	55	Extension of MTPJ from neutral	Extension of IPJ from neutral
7	M	25	20	40	60	Extension of MTPJ from neutral	Extension of IPJ from neutral
8	M	29	10	20	30	No extension but no toe drop	No extension but no toe drop
9	M	20	20	35	55	Extension of MTPJ from neutral	Extension of IPJ from neutral
10	M	27	20	40	60	Extension of MTPJ from neutral	Extension of IPJ from neutral
11	M	43	15	20	35	Extension of MTPJ from neutral	Extension of IPJ from neutral
12	M	40	10	25	35	Extension of MTPJ from neutral	Extension of IPJ from neutral
13	M	32	20	40	60	Extension of MTPJ from neutral	Extension of IPJ from neutral
14	M	29	20	35	55	Extension of MTPJ from neutral	Extension of IPJ from neutral
15	M	44	15	20	35	Extension of MTPJ from neutral	Extension of IPJ from neutral

Abbreviations: DF, dorsiflexion; F, female; IPJ, interphalangeal joint; M, male; MTPJ, metatarsophalangeal joint; PF, plantarflexion; ROM, range of motion.

effectively correct the foot drop but it has no effect on the toe drop; flexion deformity of the toes may become even worse after restoration of the ankle dorsiflexion. In this situation, a percutaneous tenotomy of long flexor tendons is one solution but there is no active toe extension.

With this technique, the long flexor tendons were released but not sacrificed; they were transferred along with the PTT to the dorsum of the foot to restore toe extension. The short flexor tendons remained intact so they were able to stabilize and flex the MTP and PIP joints and prevent any risk of clawing. Postoperative evaluation of the toes showed no toe drop in any of the patients and active toe extension in 80% of patients. However, in the study of Vigasio,[9] only 87.5% of patients showed no toe drop and 69% could actively dorsiflex their toes. Hastings et al studied the kinetics and kinematics after the Bridle procedure and showed that it does not include a component to restore active hallux and toe extension, and the lack of hallux extension was evident during the swing phase of walking.[3] Postoperative evaluation of the ankle range of motion in this study showed that the mean active range of motion of the ankle was 46 degrees, which was better than the mean of 30.4 degrees in the study of Ozkan.[7] It showed that transferring the FDL and FHL to the toe extensors not only restored toe extension, but also helped the transferred PTT to achieve a more balanced ankle range of motion.

I believe that releasing and transferring of the FDL and FHL to the toe extensors along with the anterior transfer of the PTT neutralized the deforming forces and gave the patient a better chance of active toe extension and strengthened ankle dorsiflexion. The intact short flexor tendons were able to stabilize and flex the MTP and PIP joints and the patient had control over the toes with active range of motion.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author received no financial support for the research, authorship, and/or publication of this article.

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