Partial Tibial Nerve Transfer to the Tibialis Anterior Motor Branch to Treat Peroneal Nerve Injury After Knee Trauma

Jennifer L. Giuffre MD, Allen T. Bishop MD,
Robert J. Spinner MD, Bruce A. Levy MD,
Alexander Y. Shin MD

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Abstract

Background Injuries to the deep peroneal nerve result in tibialis anterior muscle paralysis and associated loss of ankle dorsiflexion. Nerve grafting of peroneal nerve injuries has led to poor function; therefore, tendon transfers and ankle-foot orthotics have been the standard treatment for foot drop. **Questions/purposes** We (1) describe an alternative surgical technique to obtain ankle dorsiflexion by partial tibial nerve transfer to the motor branch of the tibialis anterior muscle; (2) evaluate ankle dorsiflexion strength using

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

This work was performed at the Mayo Clinic, Rochester, MN, USA.

J. L. Giuffre
Department of Surgery, Section of Plastic Surgery,
Pan Am Clinic, University of Manitoba, 75 Poseidon Bay,
Winnipeg, MB R3ME4, Canada
e-mail: jgiuffre@panamclinic.com

A. T. Bishop, B. A. Levy, A. Y. Shin (✉)
Department of Orthopedic Surgery, Mayo Clinic, 200 First
Street, SW, Rochester, MN 55905, USA
e-mail: shin.alexander@mayo.edu

A. T. Bishop
e-mail: bishop.allen@mayo.edu

B. A. Levy
e-mail: levy.bruce@mayo.edu

R. J. Spinner
Department of Neurosurgery, Mayo Clinic, Rochester, MN, USA
e-mail: spinner.robert@mayo.edu

British Medical Research Council grading after nerve transfer; and (3) qualitatively determine factors that influence functional success of surgery.

Methods We retrospectively reviewed 11 patients treated with partial tibial nerve transfers after peroneal nerve injury. Pre- and postoperative motor strength was measured. Patients completed questionnaires regarding pre- and postoperative gait and disability.

Results One patient regained Grade 4 ankle dorsiflexion, three patients regained Grade 3, one patient regained Grade 2, and two patients regained Grade 1 ankle dorsiflexion. Four patients did not regain any muscle activity. Clinically apparent motor recovery occurred an average 7.6 months postoperatively. A majority of patients (nine) could walk and participate in activities. Seven patients did not wear ankle-foot orthotics and four patients did not limp. The donor deficits included weak toe flexion (two patients) and reduced calf circumference (seven patients). **Conclusion** Our observations suggest nerve transfers to the deep peroneal nerve provide inconsistent ankle dorsiflexion strength, possibly related to the mechanism of peroneal nerve injury or delays in surgery. Despite variable strength, four patients achieved M3 or greater motor recovery, which enabled them to walk without assistive devices.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

The common peroneal nerve is prone to injury because of its superficial location at the fibular neck, its low ratio of epineural to fascicular tissue, its tethering branches, and its passage through a fibrous arcade [22]. The peroneal nerve,

often ruptured in knee dislocations, can sustain an injury from its proximal origin high in the popliteal fossa to several centimeters distal to the fibular head, a distance spanning greater than 15 cm [1, 16]. The common peroneal nerve injury results in loss of sensation to the dorsum of the foot and gait-altering paralysis of the tibialis anterior and the peroneus muscles.

Traditionally three treatment options to minimize the loss of dorsiflexion exist: ankle-foot orthosis (AFO), nerve grafting with autograft nerve, and tendon transfers. Users of AFOs are generally unsatisfied and noncompliant with the device because of discomfort, hygiene, and mobility issues [1, 21]. One study suggests operative exploration is indicated in a recognized nerve laceration or any open or closed injury that fails to show recovery by clinical or electromyographic examination 3 months or more after injury [22]. Nerve grafting is rarely successful when grafts are greater than 6 cm in length [7, 17, 18, 22]; therefore, in traumatic longitudinal nerve traction injuries, in which the nerve injury is lengthy, nerve grafting may not be the optimal treatment. Posterior tibial tendon transfers and their variants (Bridle procedure, Riordan transfer) are a commonly used treatment for foot drop [6]. Although this tendon transfer has had reasonable success in allowing patients to return to ambulation without assistive devices [6], the procedure provides weak dorsiflexion and may not completely restore normal gait [15]. This procedure is fraught with long-term complications, including hindfoot valgus deformity, arthritis, and flat foot deformity [5]. Because of this, some have proposed concomitant nerve grafting with tendon transfers to improve the likelihood of functional ankle dorsiflexion [3, 20].

Nerve transfers involve the transfer of a functional but less important nerve to a distal but more important denervated nerve [2]. The rationale for nerve transfers in lieu of nerve grafting lies in the physiology of nerve regeneration. Reconstruction of motor nerves is time-dependent. Nerve grafting requires that the regenerating nerve traverse the neurorrhaphy site and migrate toward the motor end plate before the time-dependent, irreversible changes occur in the end organ. Nerve transfers can be performed with the functioning nerve coapted close to the motor end plate, thus diminishing the regeneration time necessary to reach the motor end plate. The concept of a direct nerve transfer of a tibial motor nerve branch to the deep peroneal nerve as an alternative option to restore ankle dorsiflexion in cases of peroneal nerve injury has been proposed in anatomic studies using cadaveric specimens [1, 4, 14]. These studies confirm the feasibility of transferring motor nerve branches from the tibial nerve to the peroneal nerve although they did not determine whether the nerve transfer improved strength or function.

Our purposes were to (1) describe a surgical technique to obtain ankle dorsiflexion using a partial nerve transfer

from the tibial nerve to the motor branch of the tibialis anterior muscle; (2) evaluate ankle dorsiflexion strength using British Medical Research Council (BMRC) grading after nerve transfer; and (3) qualitatively determine factors that influenced functional success of surgery.

Patients and Methods

After obtaining Institutional Review Board approval, we undertook a retrospective chart review of all 11 patients treated with nerve transfers for peroneal nerve injuries after high-energy knee trauma between 2001 and 2009. All were males with an average age of 33.8 years (range, 15–59 years). All patients underwent a partial tibial nerve transfer to innervate a motor nerve branch of the anterior tibialis muscle. Indications for the nerve transfer included any injury that failed to show clinical or electromyographic evidence of recovery of ankle dorsiflexion by 3 months postinjury, absent advancing Tinel's sign 3 months postinjury, and a damaged peroneal nerve requiring a nerve graft greater than 6 cm. Contraindications for nerve transfers included denervation of the muscle greater than 12 months from injury, severe injury to the tibial nerve (with nonfunctioning toe flexion), pre-existing peripheral neuropathy, major posterior compartment muscle injury, and other lower extremity nerve injuries. Relative contraindications included: patients older than 65 years of age, patients with major medical comorbidities that would preclude surgery or rehabilitation, and patients with injuries or abnormalities seen on nerve testing of the tibial nerve. The minimum followup was 11 months (average, 17.7 months; range, 11–32 months). No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records and diagnostic tests.

All patients sustained a high-energy injury: 10 patients had a knee dislocation, whereas one patient had a major crush of the knee. The trauma resulted in one patient with a crushed common peroneal nerve, six of the 10 patients with a knee dislocation sustained a stretch injury to the peroneal nerve, and the remaining four patients sustained a stretch injury to the point of nerve rupture (Table 1). The mechanisms of the knee dislocations were: fall from a height (two), a fall (three), a motorcycle accident (one), a snowmobile accident (two), football tackle (one), and a wrestling injury (one). There were no concomitant vascular injuries.

All patients presented with a complete injury to the common peroneal nerve with loss of sensation in the superficial and deep peroneal nerve distribution and a loss of ankle dorsiflexion and ankle eversion. Preoperative clinical and electromyographic (EMG) examination revealed complete axonal injury of the common peroneal nerve affecting both the superficial and deep portions of the

Table 1. Patient demographics and clinical assessment

Patient number	Age (years)/gender	Injury type	Time to surgery	Preoperative BRMC dorsiflexion/5	Donor nerve	Time after surgery	Postoperative BRMC dorsiflexion/5
1	59/M	Fall	6 months 7 days	0	FHL fascicle	15 months	0
2	37/M	Fall from height	3 months 9 days	0	FDL fascicle	10 months	3
3	18/M	Wrestling injury	7 months 21 days	0	FDL branch	15 months	0
4	36/M	Fall	4 months 14 days	0	Branch of posterior tibialis fascicle	20 months	3
5	15/M	Fall	3 months 20 days	0	FDL fascicle	18 months	4
6	22/M	Football injury	7 months 14 days	0	Branch to gastrocnemius muscle branch	17 months	0
7	29/M	Snowmobile accident	9 months 23 days	0	FDL branch	11 months	0
8	23/M	Snowmobile accident	3 months 23 days	0	FDL branch	32 months	1
9	26/M	Motorcycle accident	3 months 27 days	0	FHL fascicle	16 months	1
10	49/M	Fall from height	7 months 3 days	0	FDL branch	21 months	2
11	32/M	Crush	7 months 5 days	0	Branch to gastrocnemius muscle branch	20 months	3

BRMC = British Medical Research Council; M = male; F = female; FHL = flexor hallucis longus; FDL = flexor digitorum longus.

peroneal nerve. Five of the 11 patients had EMG evidence of both severe peroneal nerve injury and mild tibial nerve neuropathy, whereas the remaining six patients had isolated peroneal nerve injuries. Of the five patients with combined peroneal and tibial nerve injuries, four of the patients recovered their tibial neuropathy as confirmed by a repeat EMG 3 to 6 months postinjury. The nerve transfers in these four patients were performed after tibial nerve recovery. The nerve transfers were performed an average of 5.8 months (range, 3.3–9.8 months) after the injury. No patients underwent nerve transfer before 3 months, five patients underwent nerve transfer between 3 and 6 months, and six patients underwent nerve transfer after 6 months (range, 6.2–9.8 months).

In a supine position, the patients were positioned with a bump under the ipsilateral hip and the knee flexed. A tourniquet was applied to the upper thigh and used if needed. Use of the tourniquet impairs the nerve stimulator's ability to identify the tibial nerve motor fascicle; therefore, if a tourniquet was used, it was deflated for approximately 20 minutes to allow tourniquet-induced transient neuropraxia to resolve before choosing an appropriate tibial nerve fascicle. If indicated, the peroneal nerve was initially explored to determine the level and extent of injury. In most cases, prior knee surgery had been performed, and the peroneal nerve stumps were tagged. If it was determined that a nerve transfer would be performed, complete peroneal nerve exploration was not performed.

The nerve transfer surgery began with a midlateral incision made from the fibular head extending distally 10 to 12 cm. The common peroneal nerve was identified at

Fig. 1 The common peroneal nerve has an articular nerve branch and nerve branches to the anterior tibialis muscle. Printed with permission of the Mayo Foundation for Medical Education and Research. All rights reserved.

the fibular neck and traced distally to the articular branch and the superficial and deep peroneal nerve branches (Fig. 1). The deep peroneal nerve was traced distally

Fig. 2 The peroneal nerve is identified proximally. Distally, a visible fat stripe demarcates the interval between soleus and peroneus longus muscles.

Fig. 3 The fat stripe interval is opened in a distal to proximal fashion with elevation of the soleus from fibula. Printed with permission of the Mayo Foundation for Medical Education and Research. All rights reserved.

beneath the lateral compartment muscles. The interval between soleus and peroneus longus was identified by its visible fat stripe (Fig. 2). An interval was created in a distal to proximal direction, elevating the soleus origin from the lateral and posterior aspect of the fibula (Fig. 3). The posterior surface of the fibula was visualized with the peroneal artery and vena comitantes. The tibial nerve and posterior tibial vessels were identified lying medial and posterior to the fibula (Fig. 4). The peroneal muscles were subperiosteally elevated from the anterior surface of the fibula to expose the articular, superficial, and deep branches of the peroneal nerve. The articular branch forms as part of the trifurcation of the common peroneal nerve: into the deep peroneal nerve, the superficial peroneal nerve, and the articular branch.

The proximal tibialis anterior branch often arises from the articular branch or as a separate branch at the level of the trifurcation (Fig. 5). Occasionally, multiple branches to the tibialis anterior muscle exist. In these cases, the common tibialis anterior motor nerve should be identified proximally (Fig. 6). The tibialis anterior motor branch(es) were divided at this level and inspected under magnification for healthy-appearing fascicles. Further sectioning was performed as needed to ensure healthy-appearing nerve (Fig. 7).

Nerve branches or fascicles that innervate the FHL, FDL, gastrocnemius, or posterior tibialis muscle were identified from the tibial nerve using a handheld disposable nerve stimulator with a current of 1 to 2 mA (Varistim III; Medtronic Xomed, Jacksonville, FL).

Fig. 4 Distally, the tibial nerve and posterior tibial vessels medial and posterior to fibula are identified. Proximally, the peroneal nerve branches into the articular, superficial, and deep branches.

Fig. 5 Tibialis anterior nerve branches arise from the deep peroneal nerve.

A fascicle-producing flexor digitorum longus function or flexor hallucis longus function was generally selected. An intraneural dissection of the tibial nerve was performed in five patients to separate donor fascicles from the rest of the tibial nerve to match the size of the tibialis anterior motor nerve. A tibial nerve branch was used in six patients (Table 1). The determination of whether a nerve branch or a fascicle was used depended on the diameter of the donor nerve relative to the recipient nerve, the branching nerve anatomy, the location, and length of the donor nerves (Fig. 8). Although it is possible to transpose the chosen tibial nerve fascicles to the peroneal nerve

stump superficially (over top of the fibula) for neuro-rhaphy, a more direct path is possible by developing a plane deep to the fibula at the level of the proximal fibular shaft. Using blunt dissection, the interosseous membrane is opened allowing direct nerve transposition for repair (Fig. 9). We divided the chosen donor fascicle(s)/branch distally with sufficient length to allow direct coaptation to the tibialis anterior motor branch without tension or a graft (Fig. 10). An end-to-end repair was performed with an operating microscope using epineural sutures. Our preference is to use a collagen nerve tube split longitudinally and wrapped around the repair and

Fig. 6 Multiple deep peroneal nerve branches innervate the tibialis anterior muscle as seen in a line drawing. Printed with permission of the Mayo Foundation for Medical Education and Research. All rights reserved. The articular nerve branch is not shown.

Fig. 7 Sectioning of the peroneal nerve proximally identifies healthy nerve fascicles.

augment the repair with fibrin glue (Baxter Healthcare Corporation, Westlake Village, CA) to both protect the repair from scar and potential disruption [7]. The wound was appropriately drained if necessary, a layered closure performed, and the knee and ankle immobilized in a bulky dressing with plaster support.

Postoperatively, the knee and ankle were immobilized and nonweightbearing for 3 weeks to protect the nerve transfer. After 3 weeks, the knee and ankle ROM and weightbearing status were guided by the reconstructive procedures previously performed on the knee.

Patients were followed at 3-month intervals with a repeat EMG at each of the visits. Serial clinical examinations for tibialis anterior muscle contraction and ankle dorsiflexion were evaluated as evidence of reinnervation. We graded perioperative motor strength of ankle dorsiflexion using the BMRC [10] scheme. All patients were

contacted by telephone or mail and asked to complete a questionnaire (Appendix 1) to determine ankle dorsiflexion function, complications, and disabilities. The required or preferred use of an AFO for ambulation and the ability to participate in activities, walking, running, and climbing stairs was determined. Complications or donor site morbidities as a result of the nerve transfer were identified. Time to clinical recovery and the first evidence of EMG recovery were determined either by appreciable contraction of the anterior tibialis muscle on physical examination or reinnervation of the anterior tibialis muscle seen on EMG.

Results

After the nerve transfer, four of 11 patients obtained M3 or greater motor recovery of ankle dorsiflexion that enabled them to ambulate without assistive devices. Of the 11 patients, one patient had restoration of Grade 4 ankle dorsiflexion, three patients regained Grade 3, one patient regained Grade 2, and two patients regained Grade 1 ankle dorsiflexion (Fig. 11). Four patients did not regain any muscle activity. The completed questionnaire revealed nine patients were able to walk barefoot, run, navigate stairs, and participate in activities. All patients had returned to their preinjury occupation. After the nerve transfer, seven patients did not wear an AFO and four patients did not limp.

Although the number of patients was too small to perform statistical analysis, several factors tended to suggest greater functional return. There tended to be an advantage in obtaining increased strength in ankle dorsiflexion in those patients who were younger and who underwent early

Fig. 8A–B An epineurotomy of the tibial nerve with separation of fascicles suited for nerve transfer is undertaken, as seen in (A) a line drawing. Printed with permission of the Mayo Foundation for Medical Education and Research. All rights reserved. (B) A surgical dissection. The articular nerve branch is not shown. The nerve branch to the tibialis anterior muscle has been prepared for transfer.

Fig. 9 The interosseous membrane is opened (blue arrow) to allow for direct transposition of the selected tibial nerve fascicle to the peroneal nerve target. The articular nerve branch is not shown. Printed with permission of the Mayo Foundation for Medical Education and Research. All rights reserved.

Fig. 10A–B The tibial nerve fascicle is transposed to the target peroneal nerve without any tension or a graft (**A**). A neuro-rhaphy is performed under an operating microscope. The articular nerve branch is not shown (**B**). Printed with permission of the Mayo Foundation for Medical Education and Research. All rights reserved.

nerve transfer before 6 months. Of those four patients with M3 or greater recovery, the average age was 30 years (range, 15–37 years) and the average time to surgery was 4.6 months (range, 3.3–7.2 months). Three of these four patients underwent nerve transfer between 3 and 6 months. Of the seven patients with M2 or less recovery, the average age was 32 years (range, 18–59 years) and the average time to surgery was 6.5 months (range, 3.8–9.8 months). Five of these seven patients underwent nerve transfer after 6 months. Motor recovery if present was clinically apparent on average 7.6 months postoperatively (range, 2.7–14.2 months).

No complications were encountered during the 11 procedures. The morbidity encountered after the nerve transfer included a donor deficit of weak toe flexion in two patients and reduced calf circumference in seven patients. There was no compromise to the function of the

tibial nerve and therefore normal plantar flexion strength in all patients.

Discussion

Foot drop secondary to peroneal nerve injury is devastating for some patients with limited options for treatment. Compliance with AFOs can be challenging because they are cumbersome, uncomfortable, and lifelong. Given that many patients have acquired a foot drop by a longitudinal traumatic stretch injury to the peroneal nerve, neurolysis and/or nerve grafting has not resulted in successful restoration of ankle dorsiflexion [17, 22]. Posterior tibial tendon transfers and their variants, although a reasonable treatment option for foot drop, provides only weak ankle dorsiflexion [15] and is fraught with long-term complications [5]. Nerve transfers

Fig. 11A–C Postoperative results from a partial tibial nerve transfer to the tibialis anterior motor branch for the treatment of peroneal nerve injury (**A**). Bilateral feet in neutral position (**B**). Bilateral feet in dorsiflexion (nerve transfer performed on left lower extremity) (**C**). Left foot in: (1) neutral; (2) dorsiflexion; and (3) plantarflexion after nerve transfer.

have recently been described in the upper extremities to restore movement and function [8, 9, 11, 13, 19]. Success of upper extremity nerve transfers has stimulated the potential use of nerve transfers in the lower extremity as a treatment alternative to orthoses or tendon transfer surgery. Nerve transfer is advantageous in that it bypasses the zone of injury, it obviates the need for an intercalary nerve graft, and it decreases the time to regeneration by performing the neurorrhaphy close to the end organ.

This study had several limitations. First, the cohort had a small number of patients. Second, there was a relatively short followup period ranging from 11 to 32 months. Third, manual muscle motor testing, despite its acceptance as an outcome measure, is a subjective measure. Fourth, the variable patient population with differing injuries may confound the results by precluding any statistical analysis. Finally, there was a relative delay to nerve surgery after injury ranging from 3.3 to 9.8 months. These limitations notwithstanding, this study demonstrates motor strength of the tibialis anterior muscle can be obtained with partial nerve transfer of the tibial nerve. This is a technique in evolution given that nerve transfers in the lower extremity are relatively new compared with upper extremity nerve transfers. Larger prospective clinical studies are needed to confirm the success of nerve transfers to obtain ankle dorsiflexion and the variables that could potentially predict

favorable or unfavorable function after partial tibial nerve transfers to the anterior tibialis motor branch in the treatment of peroneal nerve injuries after high-energy trauma to the knee.

Nath et al. [12] reported on seven of nine patients who successfully regained BMRC Grade 4 or greater ankle dorsiflexion after tibial nerve transfers for deep peroneal nerve injuries. The remaining two of the nine patients obtained Grade M0 ankle dorsiflexion after the transfer. Of those patients with M4 or greater ankle dorsiflexion, the average patient age was 33 years (range, 16–58 years) and the average time to surgery was 4.8 months (range, 2–6 months). The two patients with Grade M0 ankle dorsiflexion were an average age of 68 years (range, 66–70 years) with an average time to surgery of 7.5 months (range, 6–9 months). When comparing the patients in the present study with those in the study of Nath et al. [12] study, with M3 or greater return of ankle dorsiflexion after nerve transfer, there was no difference in the average age of the patients or in the average time to surgery. Both studies showed a trend toward a more favorable outcome in younger patients and patients who underwent earlier surgery, although the number of patients in our study was too small for statistical analysis (Table 2). There was, however, a major difference between this study and that of Nath et al. with regard to the mechanism of peroneal nerve injury. In Nath et al.'s study, only one patient had a

Table 2. Comparison of ankle dorsiflexion obtained after lower extremity nerve transfers between two studies

Authors	Patients with $\geq$ M3	Patients with $\leq$ M2	Patient age (years)		Time to surgery (months)		Mechanism of injury
			$\geq$ M3	$\leq$ M2	$\geq$ M3	$\leq$ M2	
Nath et al. [12] (N = 9)	7	2	33 (16–58)	68 (66–70)	4.8 (2–6)	7.5 (6–9)	One high-energy injury
Giuffre et al. (current study) (N = 11)	4	7	30 (15–37)	32 (18–59)	4.6 (3.3–7.2)	6.5 (3.8–9.8)	Eleven high-energy injuries

high-energy mechanism of injury. The remaining eight patients had low-energy injuries or proximal-level injuries: six patients had proximal sciatic nerve injury, two patients had a tumor of the peroneal nerve, and only one patient had a knee-level injury. Essentially, only three of the nine patients had a direct peroneal nerve injury and only one of these three patients had a high-energy mechanism of injury. These injuries are fundamentally different from the avulsion and crush injuries the patients in the present study were exposed to; therefore, the outcomes described in Nath et al.'s series are far more favorable. All patients in our study sustained high-energy trauma directly to the peroneal nerve.

Our observations suggest that in severe traumatic peroneal nerve injuries, nerve transfers to the motor nerve branch of the anterior tibialis muscle can achieve M3 or greater motor recovery. This technique is in evolution. There are some patients who are able to obtain M3 and even M4 ankle dorsiflexion, although owing to

the small numbers and uncontrolled variables, we did not attempt to identify prognostic variables. Younger age, earlier time to surgery, isolated peroneal nerve injuries with sparing of the tibial nerve, and a low-energy mechanism of injury may be factors in determining successful ankle dorsiflexion after nerve transfers. The benefit of performing a nerve transfer is that ankle dorsiflexion is restored using the intended anterior tibialis muscle for ankle dorsiflexion with minimal donor site morbidity. Tendon transfers disrupt the posterior tibialis muscle and create a semblance of normal line of pull of the anterior tibialis muscle, however not exact, therefore leading to long-term complications [5]. An additional advantage is the tibial nerve is not injured during the transfer; therefore, if inadequate ankle dorsiflexion is obtained with the nerve transfer, the option for subsequent tendon transfers exists. One may even consider doing a combined nerve transfer and posterior tibial tendon transfer for optimal ankle dorsiflexion.

Appendix 1. Peroneal nerve function questionnaire

1. How do you rate your ability to walk barefoot?			
<i>Never walks barefoot</i>	<i>Only very carefully</i>	<i>Can, but with hesitation</i>	<i>Normal barefoot walking</i>
2. How do you rate your ability to run or jog?			
<i>Unable to run or jog</i>	<i>Can jog with great difficulty</i>	<i>Can with minimal difficulty</i>	<i>Normal run/jogging ability</i>
3. How do you rate your ability to navigate stairs?			
<i>Unable to navigate stairs</i>	<i>Can with great difficulty</i>	<i>Can with minimal difficulty</i>	<i>Normal stair navigation ability</i>
4. How do you rate your ability to participate in physical activity?			
<i>Severely hindered</i>	<i>Moderately hindered</i>	<i>Minimal hindrance</i>	<i>Normal participation</i>
5. How many times per week/month do you injure your foot as a result of dragging your toes?			
<i>Multiple times per day</i>	<i>Once per day</i>	<i>Once per week</i>	<i>Less than once per week</i>
6. How often have you tripped or fallen as a result of your foot drop?			
<i>Daily</i>	<i>Weekly</i>	<i>Monthly</i>	<i>Less than once per month</i>
7. How often have you used the assistance of an ankle orthotic brace?			
<i>Daily</i>	<i>First year post-surgery</i>	<i>First 6 months post-surgery</i>	<i>Never</i>
8. Since surgery, have you noticed any changes in your ability to:			
a. Stand on your toes with your affected leg?			
<i>Much weaker than before</i>	<i>Weaker than before</i>	<i>Slightly weaker than before</i>	<i>No change post-surgery</i>
b. Support the arch of your foot?			
<i>Lost most support</i>	<i>Lost some support</i>	<i>Lost only minimal support</i>	<i>No loss of arch support</i>
c. Push down with your big toe?			
<i>Can not curl or push toe down</i>	<i>Toe is moderately weaker</i>	<i>Toe is only slightly weaker</i>	<i>Toe has normal strength</i>
9. Since surgery, have you noticed a change in your calf circumference?			
<i>Calf size is greatly reduced</i>	<i>Calf size is moderately reduced</i>	<i>Calf size is only slightly reduced</i>	<i>No change in calf size</i>
10. Since surgery, have you sought care for your injury from other medical professionals?			
<i>Podiatrist</i>	<i>Chiropractor</i>	<i>Physical therapist</i>	<i>Second opinion from surgeon</i>
11. Since surgery, have you sustained an ankle sprain or fracture?			
<i>Multiple ankle injuries</i>	<i>2-3 ankle injuries</i>	<i>Once</i>	<i>Never</i>
12. Since surgery, how would you characterize your limp without an ankle brace?			
<i>Worse than before surgery</i>	<i>Same as before surgery</i>	<i>Better than before surgery</i>	<i>No limp</i>
13. Since surgery, how do you rate your ability to return to normal work duties?			
<i>Has not returned to work</i>	<i>Returned, unable to perform as previously</i>	<i>Returned, performs with only slight changes</i>	<i>Normal function at work</i>
14. Do you wear a support brace?			
<i>None of the time</i>	<i>Some of the time</i>	<i>Only with activities</i>	<i>Always</i>
15. Are you satisfied with surgery?			
<i>Yes</i>	<i>No</i>		
16. Would you recommend this surgery to a friend in a similar situation?			
<i>Yes</i>	<i>No</i>		

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