End-to-side nerve transfer for management of chronic anterior leg compartment muscle weakness

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Purpose

- The primary goal of this retrospective study is to determine if surgical end-to-side nerve anastomosis from a muscular branch of the superficial peroneal nerve (SPN) to a branch of the deep peroneal nerve (DPN) in the proximal ⅓ of the leg is a viable option for the management of chronic anterior leg compartment muscle weakness.

Literature Review

- There are few management options for anterior compartment muscle weakness
- A foot and ankle orthosis can help immobilize the ankle at 90 degrees but does not stimulate active ankle dorsiflexion[1]
- Tibialis posterior tendon transfer may restore some active ankle dorsiflexion, but may have sequelae complications of hindfoot valgus and flatfoot deformity[1]
- The concept of nerve transfer for functional loss have been described in several literature for lower extremity
- Concepts of inter-positional nerve grafting of less than 6cm and end-to-end nerve transfer of the fascicles of SPN or tibial nerve directly to the tibialis anterior muscle or DPN have shown significant clinical improvement on ankle dorsiflexion[2-5]
- Our goal is to ascertain if a different technique, surgical end-to-side nerve anastomosis can improve ankle dorsiflexion. Our technique uses a muscular branch of the SPN and does not compromise the main fascicles of the superficial peroneal nerve

Patient Selection

- 17 patients (9 males, 8 females) underwent end-to-side nerve anastomosis from a muscular branch of SPN to a muscular branch of the DPN in the proximal ⅓ of the leg
- All patients demonstrated preoperative weakness or absence of ankle dorsiflexion due to an injury to a branch of the deep peroneal nerve
- Patients who had compromised ankle dorsiflexion due to reason of myopathy, hereditary neuromuscular disease, or more proximal nerve injuries to the common peroneal branch were excluded
- All patients underwent electromyography (EMG) testing, which showed no pathology to muscle fibers
- All patients underwent nerve conduction velocity (NCV) testing, which identified DPN involvement within the proximal ⅓ of the leg
- All patients failed non-operative therapies and/or treatments, including varying modalities of physical therapy and bracing

Study Design

- All procedures performed by one surgeon, E.R.R.
- All pre and post operative data recorded by the same surgeon
- Pre and postoperative clinical muscle strength grading were recorded based on British Medical Research Council Scale for Muscle Strength Grading (BMRC) (Table 1)
- Mechanism of injury, gender, total time of post-operative follow up were recorded (Table 2)

The British Medical Research Council Scale for Muscle Strength

Table 1: The British Medical Research Council Scale for Muscle Strength (BMRC)

Grade	Description
M5	Normal Power
M4	Movement against gravity and resistance
M3	Movement against gravity (no resistance)
M2	Movement with gravity eliminated
M1	Muscle contraction with no movement/flicker
M0	Total paralysis

Pre and Post-operative Data

Patient #	Gender	Date of Operative Intervention	Follow-up (Years)	History of Original Injury	Pre-operative Ankle Dorsiflexion (BMRC Grade)	Post-operative Ankle Dorsiflexion (BMRC Grade)
1	M	8/2018	1	ANKLE SPRAIN	2	4
2	M	5/2018	1	TKA	2	4
3	F	3/2018	1	ACL	1	4
4	M	1/2018	1	WEBER C	1	4
5	M	1/2018	1	WEBER C	1	5
6	M	9/2017	2	WEBER B	1	3
7	F	5/2017	2	TKA	2	5
8	F	4/2017	2	KNEE CONTUSION	1	4
9	F	3/2017	2	WEBER B	0	4
10	F	2/2017	2	ANKLE SPRAIN	1	4
11	M	1/2017	2	KNEE CONTUSION	0	4
12	M	8/2016	3	ACL	1	4
13	M	6/2016	3	KNEE DISLOCATION	2	4
14	F	5/2016	3	ACL	0	4
15	F	4/2016	3	KNEE DISLOCATION	2	5
16	F	3/2016	3	ANKLE SPRAIN	2	5
17	M	2/2016	3	TKA	1	4

Table 2: Pre operative and post operative patient data

Abbreviations:
BMRC = British Medical Research Council
WEBER B = Danis Weber Ankle Fracture Classification Type B
WEBER C = Danis Weber Ankle Fracture Classification Type C
ACL = Anterior Collateral Ligament (knee injury)
TKA = Total Knee Arthroplasty

Procedure

- All patients underwent an external neurolysis of the common, deep, and the superficial peroneal nerve(s) within the proximal ⅓ of the leg
- Intraoperative nerve stimulation testing was performed on the common peroneal nerve, and on the branches of the deep peroneal nerve that innervates the anterior tibialis muscle until the nerve and area of injury was identified (Figure 1)
- The superficial peroneal nerve and its muscular branches were identified and tested for function (Figure 2)
- Once the two appropriate nerves were identified, an end-to-side anastomosis from a muscular branch of the SPN to a branch of the DPN, was performed distal to the region of suspected peroneal nerve injury (Figure 3, Figure 4)
- Verification of muscular contraction via intraoperative nerve stimulation was performed
- Wound was closed deep, and skin closed with staples
- Patients were allowed to partially bear weight, and were given post operative instructions for gradual progression to full weight-bearing as tolerated

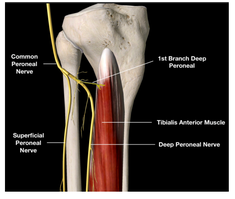

Figure 1: Illustrating the common peroneal nerve and its three general branches; the 1st branch of the deep peroneal nerve to the tibialis anterior muscle, the 2nd branch of the deep peroneal nerve, and the superficial peroneal nerve.

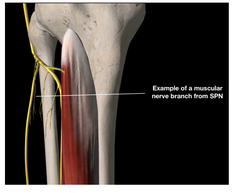

Figure 2: Illustration of a muscular nerve branch emanating from the superficial peroneal nerve which can potentially use for transfer.

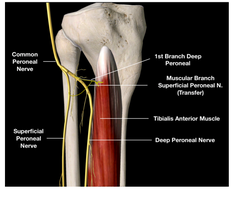

Figure 3: Illustration demonstrating superficial muscular nerve branch transfer to the 1st branch of the deep peroneal nerve.

Procedure

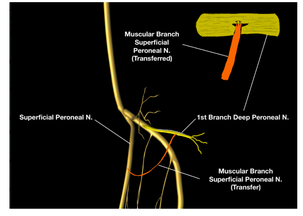

Figure 4: Illustration of an 'end-to-side' anastomosis (orange), with an epineural window created at the host site.

Results

- Retrospective study of 17 patients; 9 male and 8 females
- The average preoperative British Medical Research Council Scale for Muscle Strength grade for ankle dorsiflexion was 1.2
- The average postoperative British Medical Research Council Scale for Muscle Strength grade for ankle dorsiflexion was 4.2, (p value < 0.01)
- Average time of postoperative follow-up was 2.1 years
- Good to successful outcomes were based on British Medical Research Council Scale for Muscle Strength scores of M4 or higher
- Based on this criteria, 94.1% of patients were considered to have successful outcome. One patient had a BMRC score of 3
- There were no reported postoperative infections, no reported re-operations, or worsening of weakness following operative intervention

Analysis & Discussion

- This series reviews the success of transferring a SPN muscular branch to bypass an injured nerve region of the DPN, in order to restore muscle function and allow dorsiflexion of the ankle joint
- Continued observation with prospective protocols will invariably impact future treatment considerations for patients with this form of chronic anterior leg compartment weakness

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