Decompression of the superficial peroneal nerve: clinical outcomes and anatomical study

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OBJECTIVE The authors of this study sought to determine the outcomes of patients undergoing superficial peroneal nerve (SPN) release to treat lower-extremity pain and describe consistent anatomical landmarks to direct surgical planning.

METHODS This retrospective cohort study examined 54 patients with pain in the SPN distribution who were treated with decompression between 2011 and 2014. Patients rated pain and the effect of pain on quality of life (QOL) on the visual analog scale (VAS) from 0 to 10. Scores were then converted to percentages. Linear regression analysis was performed to assess the impact of the preoperative effect of pain on QOL, age, body mass index (BMI), and preoperative duration of pain on the postoperative effect of pain on QOL. Measurements were made intraoperatively in 13 patients to determine the landmarks for identifying the SPN.

RESULTS A higher BMI was a negative predictor for improvement in the effect of pain on QOL. A decrease in pain compared with the initial level of pain suggested a nonlinear relationship between these variables. A minority of patients (7 of 16) with a preoperative pain VAS score ≤ 60 reported less pain after surgery. A large majority (30 of 36 patients) of those with a preoperative pain VAS score > 60 reported improvement. Intraoperative measurements demonstrated that the SPN was consistently found to be 5 ± 1.1 , 5 ± 1.1 , and 6 ± 1.2 cm lateral to the tibia at 10, 15, and 20 cm proximal to the lateral malleolus, respectively.

CONCLUSIONS A majority of patients with a preoperative pain VAS score > 60 showed a decrease in postoperative pain. A higher BMI was associated with less improvement in the effect of pain on QOL. This information can be useful when counseling patients on treatment options. Based on the intraoperative data, the authors found that the SPN can be located at reliable points in reference to the tibia and lateral malleolus.

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KEY WORDS peripheral nerve compression; peripheral nerve pain; superficial peroneal nerve anatomy

WHILE common peroneal nerve compression is a well-recognized pathology, symptomatic compression of the superficial peroneal nerve (SPN) may be a more elusive entity with a less established treatment plan. Common peroneal decompression has been likened to carpal tunnel release, highlighting the procedure's place in the armamentarium of the surgeon to treat lower-extremity dysfunction, sensory disturbance, and pain.⁹ The diagnosis and treatment of SPN compression has not been as clearly defined. Symptomatic compression of the SPN is historically referred to as mononeuropathy of the peroneal nerve and was first described by Henry in

1945.⁸ Nearly 20 years later, Kopell and Thompson described entrapment of the SPN as it transitions from its subfascial location to a subcutaneous plane. The authors termed the syndrome "entrapment neuropathy."¹¹ Styf and Morberg demonstrated the rare nature of this entrapment syndrome in 1997.¹⁸ They reported on 480 patients with chronic leg pain and found entrapment of the SPN in 17 (3.5%) patients. They went on to report an 80% success rate with decompression of the nerve. Since the work by Styf and Morberg, others have reported on the success of SPN decompression.^{1,13,15,20}

In this study, we report outcomes following SPN release

ABBREVIATIONS BMI = body mass index; QOL = quality of life; SPN = superficial peroneal nerve; VAS = visual analog scale.

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to address lower-extremity pain. We also report on the consistent anatomical landmarks from our surgical experience that were used to safely decompress the SPN.

Methods

Following institutional review board approval, patient data were reviewed in a retrospective fashion from all patients who underwent decompression of the SPN for lower-extremity pain between 2011 and 2014. All patients were treated by the senior author (S.E.M.). Patients were treated with decompression of either the SPN only or a combination of decompression of the SPN, common peroneal nerve at the fibular head, and deep peroneal nerve at the dorsum of the foot. Inclusion criteria included patients with nerve compression symptoms in the SPN distribution with or without motor dysfunction. Nerve compression symptoms included numbness, paresthesia, hyperesthesia, and burning-type pain. Patients were required to have at least 1 postoperative follow-up visit, and their records needed to contain a complete pre- and postoperative pain evaluation form. The preoperative evaluation was taken at the last preoperative visit, and the postoperative evaluation was taken at the patient's last follow-up visit. These evaluations were not standardized to a specific time point. Patients with lacerated SPNs resulting in neuroma or those with a tumor of the SPN were excluded.

Demographic information was obtained and included age, body mass index (BMI), duration of pain, history of diabetes, smoking status, concomitant symptoms including other areas of nerve compression and polyneuropathy, and average follow-up time. Patients filled out our standard pain evaluation forms both pre- and postoperatively. Patients rated their baseline pain and the effect of pain on their quality of life (QOL) on the visual analog scale (VAS). These scores ranged from 0 to 10 and were then converted to percentages. Patients also marked their area of pain on a body diagram. To determine our most useful outcome measure for patients with complicated nerve pain, we looked to the study by Ebersole et al.⁶ When examining responsiveness on the Disabilities of the Arm, Shoulder, and Hand (DASH) Questionnaire as an outcome measure following ulnar nerve transposition, the authors found that VAS was highly responsive and the "impact of pain on quality of life" scale was the most responsive.⁶ Given this, we chose to evaluate pain in relation to its effect on QOL when analyzing SPN decompression.

Clinical Evaluation

Patients were evaluated for sensation in the SPN distribution using the ten test. The ten test has been clinically evaluated and shown to have good interobserver reliability for sensory evaluation.¹⁷ For this test, patients rank sensation from 1 to 10, with 10 being equivalent to normal sensation. Sensation in the deep peroneal nerve distribution on the dorsum of the foot was also tested. Motor function was evaluated using the Medical Research Council scale. Nerve compression was evaluated with the Tinel test and the scratch-collapse test. The scratch-collapse test has been shown to be a useful tool for identifying areas of nerve compression and can be used to identify multiple areas of

compression in patients with complicated nerve pain.^{2,3,7} Electrical study results were also considered, although positive findings were not a prerequisite for surgery.

Statistical Analysis

A multivariate linear regression analysis was performed to assess the impact of the preoperative effect of pain on QOL, age, BMI, and the preoperative duration of pain on the postoperative effect of pain on QOL. Other potential covariates were excluded to keep the number of covariates in the model in line with the sample size. The patient's postoperative assessments of pain were similarly evaluated using multivariate linear regression with preoperative pain, age, BMI, and preoperative duration of pain as the independent variables.

For all tests, *p* values < 0.05 were considered significant. Statistical analyses were performed using SPSS statistical software (version 22, IBM).

Anatomical Data

Intraoperative measurements were gathered from the charts of 13 patients. The distance from the lateral malleolus to the fibular head was measured. The location of the SPN in relation to the most anterior aspect of the tibia and the lateral malleolus was recorded. Specific branching patterns of the SPN were noted.

Results

Fifty-four patients underwent SPN release with or without common peroneal nerve release and deep peroneal nerve release. Five patients had SPN release only, 8 patients had SPN and deep peroneal nerve release, and the remaining patients underwent SPN and common peroneal release with or without a deep peroneal nerve release. Eleven patients had the ipsilateral common peroneal nerve released in a previous operation. Demographic information is summarized in Table 1. The mean age $\pm$ standard deviation was 46.4 ± 16 years. There were 30 women and 24 men. The average BMI was 28.3 ± 6 . The average follow-up time was 4.3 months (range 1–24 months). Seven patients had diabetes, and 3 of those patients had evidence of peripheral neuropathy. Overall, 31 patients reported concomitant symptoms, including peripheral neuropathy, chronic back pain, and nerve compression symptoms at other sites. Active smoking was noted in 18 patients. Eleven patients developed symptoms after hip or knee surgery. Eight patients reported pain after foot or ankle surgery. Thirteen patients noted pain in the SPN distribution after trauma such as an ankle injury or a fall. Two patients had pain after saphenous vein harvest. The remaining patients had idiopathic pain.

The average baseline and pre- and postoperative VAS pain scores were 68% and 46%, respectively. The average pre- and postoperative effects of pain on QOL were 78% and 53%, respectively. The average duration of symptoms was 26.5 months (range 1–132 months) before decompression of the SPN was performed. Only 3 cases involved workers' compensation. A positive Tinel or scratch-collapse test was found at the fibular head in 41 patients, over some portion of the SPN in 49 patients, and over the deep peroneal nerve on the dorsal foot in 22 patients. Forty-

TABLE 1. Demographic data

Variable	Value*
Age, yrs	46.4 ± 16
Sex, n	
Female	30
Male	24
BMI	28.3 ± 6
Duration of pain prior to surgery (mos)	26.5 ± 30
Time to last follow-up (mos)	4.3 ± 5.4
Preop VAS pain score, %	68
Postop VAS pain score, %	46
Preop effect of pain on QOL, %	78
Postop effect of pain on QOL, %	53

* Data are presented as the mean ± SD unless noted otherwise.

three patients underwent electrical studies. Six patients were noted to have pathology of the SPN on electrical studies. Seven patients had studies that were read as normal. Twenty-four patients had electrical evidence of pathology of the common peroneal nerve around the fibular head. Only 1 patient was noted to have polyneuropathy with no areas of compression noted. Other findings included radiculopathy and sciatic compression.

BMI had a statistically significant negative effect on the postoperative effect of pain on QOL ($p = 0.027$). There were no other significant effects of the covariates on the effect of pain on QOL or postoperative pain. Diabetes had no significant effect and was left out of the final analysis to keep the number of variables analyzed in line with the sample size. The details of the analyses are shown in Table 2. The effects of pain on QOL and VAS pain score were strongly correlated preoperatively ($R^2 = 0.31$; $p < 0.001$) and postoperatively ($R^2 = 0.46$; $p < 0.001$).

The scatterplot displaying the decrease in pain compared with the initial level of pain (Fig. 1) suggests a nonlinear relationship between the variables. There was a significant difference in the mean improvement in pain for those patients with a preoperative pain score ≤ 60 on the VAS and those patients with a preoperative pain score > 60 . The mean decrease in pain among the patients with a preoperative pain score ≤ 60 was 2 ± 15 . The mean decrease in pain among the patients with a preoperative pain score > 60 was 36 ± 17 . A minority of patients (7 of 16) with a preoperative VAS pain score ≤ 60 reported less pain after surgery, while a large majority of patients (30 of 36) with a preoperative VAS pain score > 60 reported improvement.

Anatomical Data

The SPN was found to be 5 ± 1.1 , 5 ± 1.1 , and 6 ± 1.2 cm lateral to the tibia at 10, 15, and 20 cm proximal to the lateral malleolus, respectively (Fig. 2). The nerve exited the anterior intermuscular septum at 10 ± 3 cm proximal to the lateral malleolus. Two patients were found to have a separate posterior branch that was decompressed in the lateral compartment. One patient had a deep muscular course to the SPN.

TABLE 2. Multivariate regression analysis

Covariate	B Value	Significance
Improvement in effect on QOL*		
Age	0.116	0.628
Baseline effect on QOL	0.238	0.212
BMI	-1.644	0.027
Pain duration	-0.050	0.697
Postop pain†		
Age	-0.190	0.355
Baseline pain	0.122	0.512
BMI	0.173	0.786
Pain duration	0.094	0.402

* Overall model $R = 0.353$. After accounting for other covariates, as BMI increased there was less improvement in the effect of pain on QOL. This was the only association that reached significance. Age, baseline effect of pain on QOL, and pain duration were not associated with improvement in the effect of pain on QOL.

† Overall model $R = 0.214$. No variables were associated with postoperative pain.

Discussion

When we evaluate patients in our clinic for peroneal nerve compression that leads to motor and sensory disturbances, we are careful to assess the SPN and deep peroneal nerve at the lateral leg and dorsal foot, respectively. The standard pain evaluation form filled out by the patient often gives us information regarding the patient's symptoms that can direct our examination. Not only do patients fill out the VAS for pain and the effect of pain on QOL, they also mark a body diagram highlighting their area(s) of pain. They are also provided with a list of key words that help them describe their pain, such as "burning," "throbbing," "aching," "electric," and "stabbing." They are encouraged to circle as many words as needed to best describe their pain. This helps with communication in the clinic.

The examination maneuvers used include assessing for the Tinel sign over the nerve in question and the scratch-collapse test. The scratch-collapse test can be helpful for determining areas of nerve compression in complicated patients with multiple areas of pain.^{2,3,7} The ten test is also helpful for determining areas of hypesthesia that point to pathology in the SPN distribution.

The indications for release of a particular nerve include motor weakness, a positive Tinel or scratch-collapse test, sensory disturbances found with the ten test, and evidence of nerve pathology on electrical studies, although electrical studies can be normal in the setting of painful nerve compression. In our series, 80% of patients had electrical studies and a majority of patients were found to have pathology of the common peroneal nerve at the fibular head, while only 14% of patients who had electrical studies were found to have pathology of the SPN. The more important indicator of entrapment or pathology of the SPN was the Tinel or scratch-collapse test, as 91% of patients had positive provocative findings over the SPN. The use of MRI, ultrasound, or other imaging modalities is not standard in our practice.

FIG. 1. Reduction in pain versus preoperative pain. Fewer than half of the patients (7 of 16) with a preoperative VAS score ≤ 60 reported a reduction in pain. A majority of patients (30 of 36) with a preoperative VAS score > 60 reported a reduction in their pain. This cutoff value is demarcated by the red bar. Figure is available in color online only.

In those patients who had SPN release without common peroneal nerve release, there were negative provocative maneuvers at the fibular head region, no motor weakness, and the electrical studies did not show any motor disturbance.

In our series, 78% of patients underwent a combined procedure, which includes SPN release with or without deep peroneal nerve release along with release of the common peroneal nerve. The fact that most of our patients with pain in the SPN distribution had multiple points of compression along the peroneal nerve may be explained by the “double crush” hypothesis put forth by Upton and McComas in 1973. Essentially, an area of proximal compression can cause downstream areas to be more susceptible to compression.¹⁹ We alluded to this issue in our 2007 study on common peroneal nerve decompression, though at that time we did not specifically evaluate patients with SPN pain.⁹

Our algorithm for treating lower-extremity nerve pain can lead to a stepwise approach. Eleven patients who had the ipsilateral common peroneal nerve released went on to have the SPN released in a later operation. In these cases,

while the pathology of the common peroneal nerve was clear, evidence of compression of the SPN was not obvious enough to justify the risks of performing another incision on the lower extremity. If the release of the common peroneal nerve did not relieve all downstream symptoms, then appropriate patients were indicated for release of the SPN with or without release of the deep peroneal nerve.

The majority of the patients in our cohort underwent orthopedic surgery or had trauma that was temporally related to the onset of pain in the SPN distribution. The suspected cause of nerve pathology after hip and knee surgery is traction, although, in the case of foot and ankle surgery or a crush to the lower leg, edema and scarring may also play a role in compression. As a tertiary referral center for patients with peripheral nerve trauma and pain, we may have a skewed sample in regard to patients with postsurgical or posttraumatic lower-extremity nerve pain. Patients with diabetic polyneuropathy were underrepresented in this study, but the metabolic derangements related to diabetes certainly could have been a component of the nerve pathology seen.

Diabetes was present in 7 (13%) patients, and 3 of those

FIG. 2. Schematic of where the SPN is located in reference to the tibia and lateral malleolus. Figure is available in color online only.

patients had clinical or electrical studies that confirmed peripheral polyneuropathy. All 3 of the patients with signs of diabetic polyneuropathy had clinical evidence of compression or underwent electrical studies that specifically demonstrated pathology of the SPN. Although our patient population did not include patients with diabetic polyneuropathy as the sole indication for surgery, considering diabetic polyneuropathy as a source of peripheral nerve pain is important.

As diabetic polyneuropathy is the most common complication of diabetes and may affect more than 50% of patients with diabetes, this specific indication for decompression surgery can change surgical planning and patient counseling.¹² Dellon synthesized the basic science, anatomical studies, and clinical outcomes research, concluding that the peripheral nerves in patients with diabetes are susceptible to chronic compression.⁴ Clinical outcome studies revealed that peripheral nerve decompression for painful diabetic neuropathy reduces ulceration and the amputation rate, decreases hospital admissions, and decreases pain in the lower extremity.⁴ In a randomized control trial, Macaré van Maurik et al. found that decompression of the common, superficial, and deep peroneal nerves, along with the tibial nerve at the ankle, significantly improved VAS pain scores at 1-year follow-up.¹² Ducic et al. reviewed the literature on nerve decompression and presented an algorithm for surgical treatment as an adjunct to maximized medical therapy. They concluded that it is the role of the peripheral nerve surgeon to intervene in the appropriate patients in order to help halt the progression of painful peripheral neuropathy.⁵ Knobloch et al. showed promising results of lower-extremity nerve decompression for diabetic polyneuropathy in a small series of patients. They released the common peroneal nerve, deep peroneal nerve, and tarsal tunnel, but did not specifically address the SPN.¹⁰ The message seems to be that decompression of lower-extremity nerves is helpful for treating painful diabetic neuropathy.^{4,5,10,12,14,16}

Overall, 69% of patients showed some improvement in the effect of pain on QOL. These results are in line with the results of Styf and Morberg, who reported an 80% success rate in their group of 17 patients.¹⁸ The majority of patients who showed improvement in the effect of pain on QOL had a preoperative VAS pain score > 60, while only 7 of 16 (44%) patients with a VAS pain score ≤ 60 showed improvements. We derived this cutoff value by looking at the graphed data and noting the point where more patients seemed to show improvement (Fig. 1). The groups of patients with VAS pain score above and below 60 were then compared statistically. The implication is that those patients with greater pain are more likely to reap benefits from a pain-relieving procedure. This confirmation of intuition will help guide our surgical planning in the future. Still, an initial VAS pain score ≤ 60 may not serve as a definite contraindication to surgery. As pain is ultimately subjective, the VAS pain score was not the only factor that dictated the treatment plan. We also evaluated factors such as the effect of pain on activities of daily living and the effect of pain on depression, though these factors were not specifically evaluated in this study. And while it is intuitive that patients with less pain will have less improvement after decompression, this information needs to be clearly

explained to the patient so they can be a part of the decision-making process.

The limitations of this study include those inherent to a retrospective analysis. Also, there was no control group. We do not have a comparison between patients who underwent SPN release only, common peroneal only, and combined release. We do not know how much improvement patients would have seen without treatment or with a sham surgery due to the placebo effect. The noted improvement in pain could be related to regression to the mean or accommodation to pain, which would have manifested as a decrease in the effect of pain on QOL. Another issue is that we only looked at one preoperative questionnaire and the last postoperative questionnaire, precluding tests of reliability and consistency in reporting. Our average follow-up period of 4.3 months is limited and may bias results, and there was a great deal of variation in the total follow-up time. As surgery on the lower extremity can be complicated by wound-healing issues, in future prospective studies it will be important to report on the morbidity of the additional incisions needed for SPN and deep peroneal nerve release. In addition to these issues, the current study suffers from a small sample size. Thus, the statistical analyses are constrained as well as being susceptible to normal population variations.

Conclusions

Despite the limitations of the study, we can draw helpful conclusions from Fig. 1. Patients with a pain VAS score ≤ 60 did not reap the same benefits from decompression of the SPN compared with those with a VAS score > 60. A higher BMI also negatively affected improvements in QOL. This information is useful when counseling patients on the risks and benefits of the surgery. Additionally, 11 (20%) patients had pain in the SPN distribution after hip and knee surgery. These patients also had pathology of the common peroneal nerve. When evaluating patients with motor dysfunction and pain after hip and knee surgery, we are careful to assess the SPN for signs of compression. To note, our intraoperative measurements show that the SPN can be reliably found and decompressed based on its location in relation to the tibia and lateral malleolus. Since 2 of the 13 patients measured had separate branches in the posterior compartment and 1 patient had a nerve with a deep muscular course, care must be taken to identify the SPN in its entirety, thereby exposing anomalous branching patterns.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Franco, Mackinnon. Acquisition of data: Franco, Lalchandani. Analysis and interpretation of data: Franco. Drafting the article: Franco, Phillips. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Statistical analysis: Franco. Administrative/technical/material support: Mackinnon. Study supervision: Mackinnon.

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