Nerve Decompression in the Lower Leg Results in an Improvement in Symptoms in Patients With Both Diabetic and Idiopathic Polyneuropathy

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Abstract: Background: Patients suffering from polyneuropathy often complain of pain, tingling, and numbness sensations, as well as an increased risk of falling with the corresponding subsequent complications. If symptoms persist after conservative treatment options have been exhausted, nerve decompression in the lower extremity, as described by Dellon, can bring about an improvement in symptoms in many patients. Dellon originally reported that this surgery led to very successful outcomes in patients with diabetic polyneuropathy. In this study, we compare our postsurgical results in patients with diabetic versus idiopathic polyneuropathy.

Methods: Thirty-three patients with idiopathic or diabetic polyneuropathy who had undergone Dellon nerve decompression in the lower extremity between 2011 and 2013 were included in the retrospective study. Pain (numeric rating scale [NRS] 0–10; 0, no pain; 10, worst imaginable pain), tingling, numbness, Hoffmann-Tinel sign, and Semes-Weinstein monofilament were assessed in 20 patients with diabetic polyneuropathy and in 13 patients with idiopathic polyneuropathy.

Results: Three months after surgery, a significant reduction in pain was evident in patients with diabetic polyneuropathy, from a preoperative level of NRS 4.9 (minimum, 0; maximum, 10) to 2 (minimum, 0; maximum, 8; $P = 0.005$). Ninety percent of patients complained of tingling ($P = 0.000$) before surgery and 18% after surgery, whereas 100% complained of numbness before surgery and 41% ($P = 0.000$) after surgery. One hundred percent of patients had no measurable surface sensitivity before surgery (measured with the Semes-Weinstein monofilament), whereas 3 months after surgery, only 24% of patients still had no measurable surface sensitivity ($P = 0.000$). A positive Hoffmann-Tinel sign was recorded in 85% of patients before surgery and only in 11% 3 months after surgery ($P = 0.000$). In the case of patients with idiopathic polyneuropathy, a reduction in pain was evident 3 months after surgery, from a preoperative level of NRS 3.9 (minimum, 0; maximum, 9) to 2.2 (minimum, 0; maximum, 9; $P = 0.058$). Seventy-seven percent of patients complained of tingling before surgery and 42% after surgery ($P = 0.111$), whereas 92% complained of numbness before surgery and 50% after surgery ($P = 0.030$). Seventy-seven percent of patients had no measurable surface sensitivity before surgery (measured with the Semes-Weinstein monofilament), whereas 3 months after surgery, only 33% of patients still had no measurable surface sensitivity ($P = 0.047$). A positive Hoffmann-Tinel sign was recorded in 62% of patients before surgery and only in 17% 3 months after surgery ($P = 0.041$).

Conclusions: Not only patients with diabetic polyneuropathy but also those with idiopathic polyneuropathy benefit from Dellon nerve decompression surgery in the lower extremities.

Key Words: diabetic polyneuropathy, idiopathic polyneuropathy, Dellon nerve decompression

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Peripheral neuropathy is common, often distressing and sometimes disabling or even fatal. The prevalence is about 24 per 1000, rising with age to 80 per 1000.[1] Polyneuropathies are chronic and usually develop over several months.

There are various causes of polyneuropathy (PNP), diabetes mellitus, and alcoholism being the most common. In about 20% to 30% of patients, however, the causes remain unexplained.[2]

Diabetic peripheral neuropathy is one of the most common complications of diabetes. Population-based cohort studies have shown that 66% of people with type 1 diabetes and 59% of people with type 2 have objective evidence of peripheral neuropathy.[3]

Once developed, peripheral neuropathy, be it diabetic or idiopathic, is irreversible and slowly progressive. A variety of treatments has been tried with the aim of altering the metabolic abnormalities, such as aldose reductase inhibitors, nerve growth factor, and neuroleptic drugs, as well as antidepressants for symptomatic therapy, but none has proven effective.[4]

The present medical approach is designed to treat foot infections, ulcerations, amputations, and pain. Fifteen percent of patients suffering from diabetic neuropathy will typically develop an ulceration.[5,6]

Various authors have noted the huge costs of treating the complications involved in diabetic PNP,[7,8] and other authors point to the still rising number of minor and major amputations in these patients in recent years.[9,10]

In the treatment of diabetic neuropathy, the correct, respected and traditional medical approach is to attempt to achieve a euglycemic state and ensure regular care of the feet.[11,12]

For many patients with diabetes-induced or idiopathic neuropathy, the loss of sensitivity in their feet presents a major problem in addition to the pain and tingling. It is also these symptoms and the loss of balance that put the patient at risk for ulcers, increased likelihood of falling, infection, and amputation. No medication is currently available for these symptoms of sensory loss. It is this general lack of treatment options for the symptoms of neuropathy in the majority of patients with diabetes that creates a feeling of hopelessness in many of them, leading to depression and a sense of futility. Against this background, the possibility of relieving the symptoms of diabetic or idiopathic neuropathy by decompressing superimposed peripheral nerve compressions gave rise to some optimism surrounding this difficult clinical problem.[13,14]

If through careful clinical and instrumental diagnosis such patients can be identified among those patients with PNP, a significant

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Study number: No. 9751_BO_K_2021 Ethical committee of the Hannover Medical School.

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improvement in symptoms can be achieved for them by surgically decompressing the nerve at the point of narrowing. This concept was developed by Dellon,[15] originally for patients with diabetic PNP, and has meanwhile been used occasionally in patients with idiopathic PNP by Siemionow et al[16] and Valdivia Valdivia et al.[17]

In the 1988s, MacKinnon and Dellon[18] noted that most diabetic patients with carpal tunnel syndrome and symptoms of peripheral neuropathy such as numbness and tingling in their hands regained their sensation after carpal tunnel decompression surgery. The patients' pain also improved, even though it was not completely eliminated. Maloney et al[19] showed a good result from upper extremity decompression nerve surgery predicts the outcome for lower extremity decompression nerve surgery in 88% of patients. This involved relieving the focal nerve entrapment (the true pain generator), with the result that the pain suffered by the patients disappeared or was greatly diminished. An immediate improvement and improved motor function is often seen in the postoperative acute care unit after nerve decompression.[20] We wanted to use this retrospective study to demonstrate and confirm that patients with idiopathic PNP benefit from surgical nerve decompression in the lower limbs in a similar way to patients with diabetic PNP.

PATIENTS AND METHODS

We surgically treated 33 patients with PNP. One leg was affected in one of the patients and both legs in the other 32 (a total of 65 legs and 195 nerves). There were 9 women and 24 men with an average age of 67 years (from 44 to 89 years).

The symptoms our patients reported were pain, tingling, numbness, a burning sensation, weakness, and cramps in the foot, lower leg, or both. The symptoms worsened at night, during the day, or during the day and night. They were improved by walking, standing, sitting, or lying down.

All the patients with pain had been treated with medication such as Lyrica, Gabapentin, antidepressants, or opioids to relieve their pain. None of these patients had experienced sufficient symptom relief.

The inclusion criteria used to choose patients for decompression were as follows: patients aged between 18 and 90 years with symptomatic sensory deficits in the distribution of the common peroneal nerve and tibial nerve, a positive Hoffmann-Tinel (HT) test result over the peroneal nerve (fibular head) or tibial nerve in the tarsal tunnel, failure to have symptoms relieved by medical drugs, and documentation of neuropathy by measuring the nerve conduction velocity.

Exclusion criteria were limb ischemia characterized by the absence of a main artery pulse or by the absence of a pulse, an ankle brachial index of >1.0 or =1.0, an infected wound at the site of surgery, obvious pedal edema, central nervous system disease, spinal cord injury, and patients with immune deficiency disease.

The results of surgical decompression of PNP in 20 patients (39 legs and 117 nerves) with diabetes mellitus (5 patients type 1 and 16 patients type 2) were compared with 13 patients (26 legs and 78 nerves) with idiopathic PNP. All patients underwent Dellon triple surgical decompression[21] in our Plastic and Hand Surgery Department (Lüdenscheid Hospital) from January 2011 to December 2013.

For 3 months after surgery, we investigated the level of pain (according to the numeric rating scale (NRS; 0–10), tingling, numbness, HT sign, and Semes-Weinstein monofilaments (MFs) in 29 of the 33 patients. The NRS we used was applied verbally in the form of a horizontal bar, the 11-point range being from 0 (no pain) to 10 (worst imaginable pain).

Clinical evaluation included HT sign (Fig. 1) and measurement of cutaneous sensation with Semmes-Weinstein MFs. All patients with diabetic or idiopathic PNP were screened for diminished protective sensation. The MF in our study applies 10 g of force when pressed against the plantar surface of feet. The examination was performed in supine position without socks.

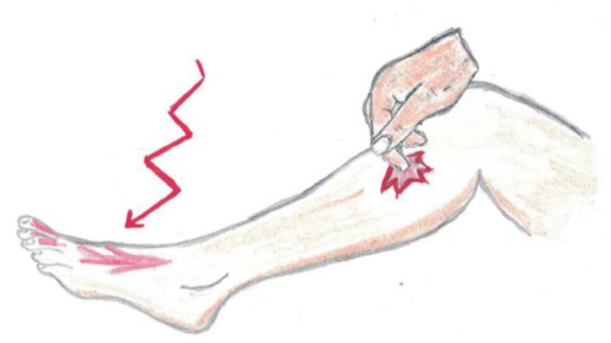


FIGURE 1. Schematic view of the HT test over the common peroneal nerve at the fibular head.

We asked patients to close their eyes. The test was positive if patients responded "yes" each time they felt the prick of the MF.

Surgical Procedures

The procedures were performed with the patient under general or spinal anesthesia. With the patient in supine position, the 2 sites were operated simultaneously using loupe magnification. The common peroneal nerve, tibial nerve, and deep peroneal nerve were decompressed as follows: a 4-cm skin incision was made obliquely across the fibular neck and continued down through the subcutaneous tissues to expose the fascia between the head of the peroneus longus and the gastrocnemius. After opening the fascia, the common peroneal nerve was exposed. A 5- to 6-cm skin incision was made above the tarsal tunnel, the fascia and flexor retinaculum were excised, and the tibial nerve and its 3 branches were identified and subjected to neurolysis (inferior calcaneal nerve, lateral plantar nerve, and medial plantar nerve). A 2- to 3-cm longitudinal skin incision was made above the deep peroneal nerve at the dorsum of the foot. The nerve was released after incising the superficial and deep fascia. Skin was closed without fascia closing; all patients were allowed to walk from the first day after surgery with elastic wrap.[21,22]

They were discharged after 2 to 3 days, and the stitches were removed 3 weeks after surgery (Figs. 2–4).

Statistical Analysis

We conducted the analysis using SPSS 26 and MINITAB 17. We used descriptive statistics as well as a proportion test, a paired *t* test, and a Friedman test.

This study was registered by the ethical committee of Medizinische Hochschule Hannover (Hannover Medical School) under No. 9751_BO_K_2021.

RESULTS

From January 2011 to December 2013, 33 patients met all the eligibility criteria. Our final study group consisted of 20 patients (60.6%) with diabetes mellitus (4 patients type 1, and 16 patients type 2). Nineteen of these patients underwent bilateral procedures, surgery being performed on a total of 38 legs, whereas one of these patients had surgery on only one leg, meaning that 39 legs were operated on in all. By comparison, 13 patients (39.4%) had idiopathic PNP. These 13 patients with idiopathic PNP had surgery on both legs, that is, 26 legs in all.

Of the 20 patients with diabetic PNP, we were able to conduct follow-up examinations on 17 patients for 3 months after surgery; of the 13 patients with idiopathic PNP, we conducted follow-up examinations on 12 patients for 3 months after surgery. Four patients could not

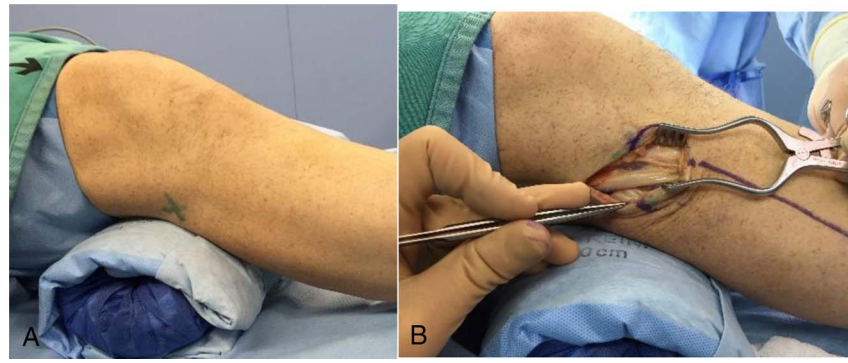


FIGURE 2. Intraoperative decompression of the common peroneal nerve at the fibular head, lateral right leg. A, Preoperative marking of the skin incision. B, Common peroneal nerve after decompression.

be contacted for follow-up examinations (1 patient died and 3 moved without providing their new address).

Group 1 Diabetic PNP

Among the patients with diabetic PNP, pain in the lower extremity was the indication for surgery in 14 patients, whereas numbness and tingling were the indication for surgery in 6 patients.

Group 2 Idiopathic PNP

In the group of patients with idiopathic PNP, pain in the lower extremity was the indication for surgery in 7 patients, whereas numbness and tingling in the lower extremity were the indication for surgery in 6 patients.

Results of Comparison of Diabetic PNP Versus Idiopathic PNP

Pain

See Figure 5.

Numbness

See Figure 6.

Sensitivity Disorders (Tingling)

See Figure 7.

Monofilament

See Figure 8.

HT Sign

See Figure 9.

Table 1 shows 2 representative cases from our study. Note that patient 19 with an idiopathic PNP did not have a positive HT but improved dramatically regarding the pain: preoperative NRS 8/10 versus postoperative NRS 0/10.

DISCUSSION

Dellon triple-nerve decompression of the lower extremity is a useful means of alleviating symptoms of diabetic and idiopathic PNP, although, in our study, patients with diabetic PNP seem to benefit more from this surgery than patients with idiopathic PNP.

Only a few studies have compared the outcomes of triple-nerve decompression of the lower extremity between patients with diabetic PNP and those with nondiabetic PNP.[16,17] Polyneuropathy is known to be an irreversible disease for which there is no cure; only its symptoms can be treated with drugs (nonsteroidal anti-inflammatory drugs, opioids, neuroleptics) with corresponding side effects.

The current explanation offered by neurologists is that diabetes causes a deposition of collagen in the small arteries that supply the peripheral nerves, causing decreased blood flow, converting the nerve in the diabetic individual to one that is ischemic, with this condition worsening the more distal you are in the nerve, causing a length-dependent sensorimotor neuropathy. In addition, there is a known metabolic problem within the peripheral nerve: this involves increased aldose reductase activity, which converts glucose into sorbitol.[23] The sorbitol is hydrophilic and draws water into the nerve, thereby causing edema of the nerve. Furthermore, there is a decrease in the slow axoplasmic transplant in the diabetic nerve, which prevents proteins needed for

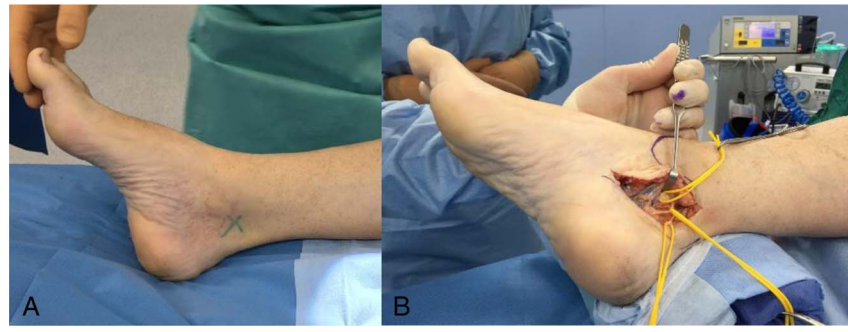


FIGURE 3. Intraoperative decompression of the tibial nerve at the tarsal tunnel, right foot. A, Preoperative marking of the skin incision. B Tibial nerve after decompression with a vessel loop around the nerve.

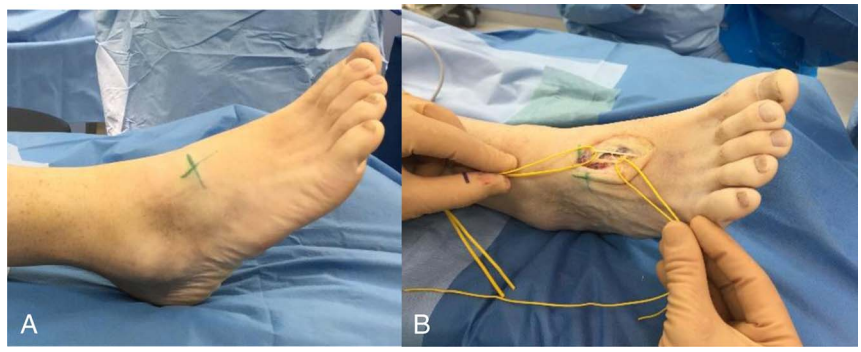
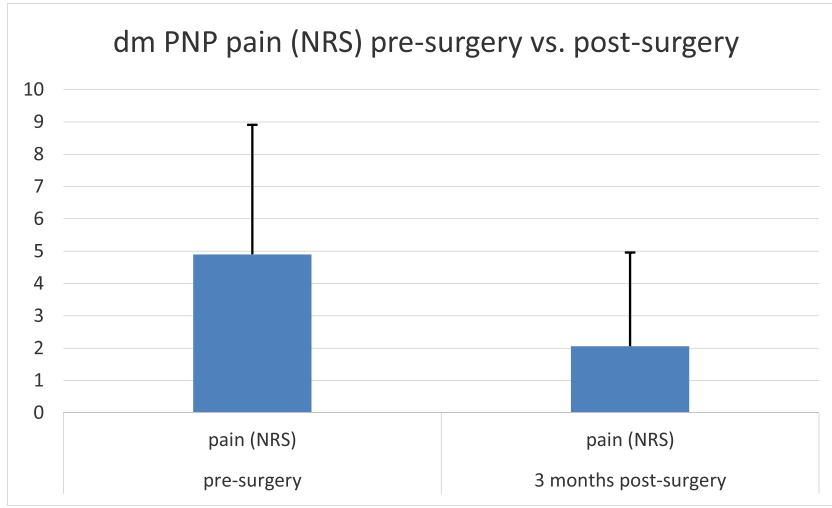


FIGURE 4. Intraoperative decompression of the deep peroneal nerve on the dorsum of the right foot. A, Preoperative marking of the skin incision. B, deep peroneal nerve after decompression with vessel loops.



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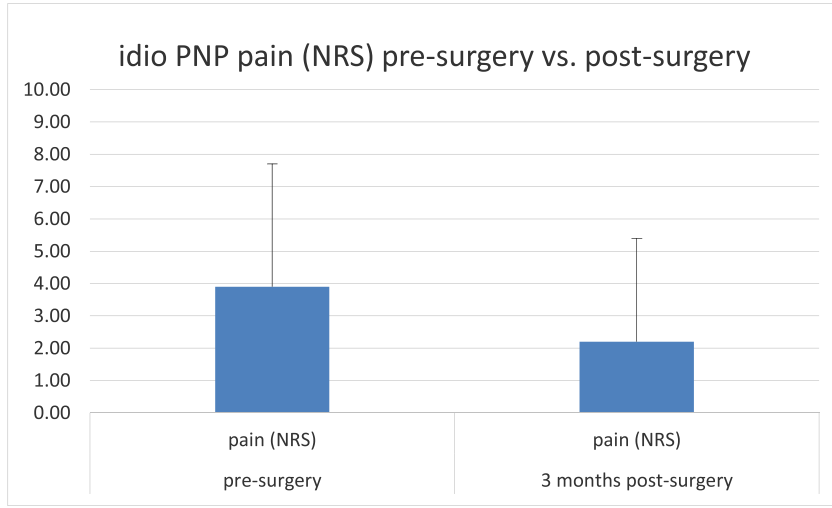

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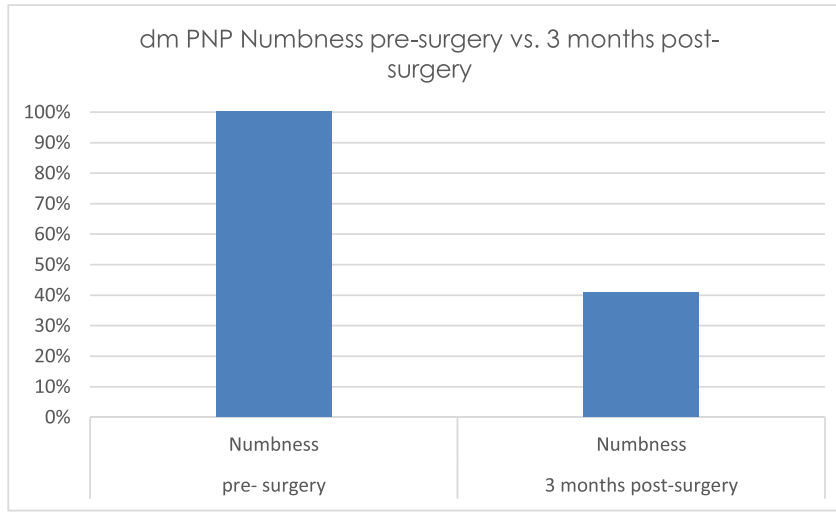
FIGURE 5. A, Comparison of pain levels in patients with diabetic PNP before surgery (NRS 4.9) and 3 months after surgery (NRS 2). $P = 0.005$. B, Comparison of pain levels in patients with idiopathic PNP before surgery (NRS 3.9) and 3 months after surgery (NRS 2.2). $P = 0.058$.



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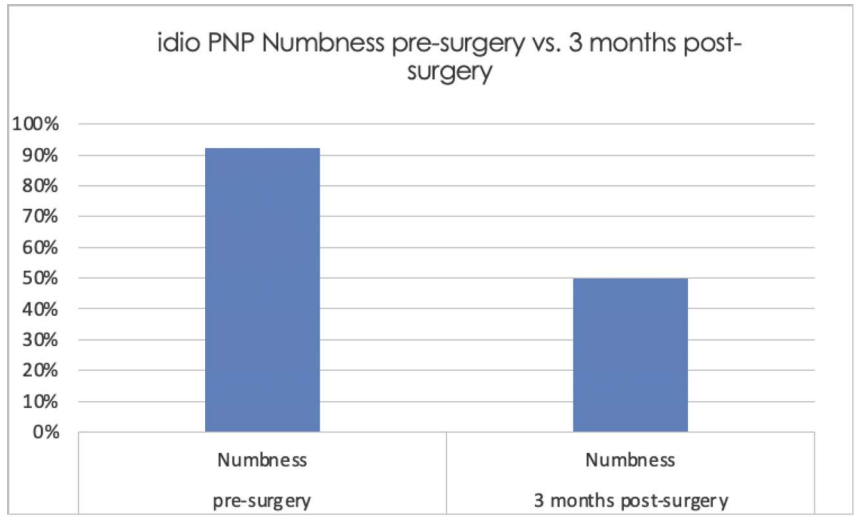

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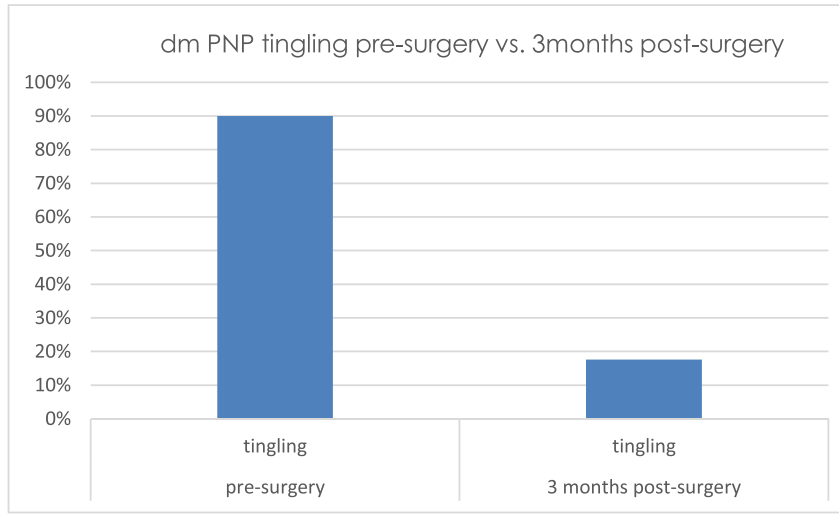
FIGURE 6. A, Comparison of sensations of numbness in patients with diabetic PNP before surgery (100% of patients complained before surgery about numbness in the legs) and 3 months after surgery (only 41% of patients were still complaining after surgery about numbness in the legs). $P = 0.000$. B, Comparison of sensations of numbness in patients with idiopathic PNP before surgery (92.3% of patients complained before surgery about numbness in the legs) and 3 months after surgery (50% of patients complained after surgery about numbness in the legs). $P = 0.030$.

structural repairs from reaching the periphery. Finally, advanced glycogen end products will most likely be deposited within the nerves.[23]

Although it has been clearly demonstrated that the prevalence of carpal tunnel syndrome increases in patients with diabetes and neuropathy, and it is universally accepted that decompression is the right way to treat chronic nerve compression in the wrist, even in patients with diabetes, applying this reasoning to chronic nerve entrapments in the lower extremity remains controversial among academic neurologists and diabetologists.[17,24,25] Theoretically, peripheral nerves in the lower extremity should respond to treatment in a manner similar to those in the upper extremity; indeed, it has been shown that a diabetic patient with neuropathy who has undergone successful carpal tunnel decompression has a 95% positive predictive value for successful neurolysis of chronic nerve compression in the lower extremity.[19] In the 1992 report by Dellon,[15] the results of nerve decompression in the upper extremity were superior to those in the lower extremity; however, it was suggested that this was because the patients with lower extremity nerve compression and neuropathy had a more advanced degree of axonal loss than those with nerve compression and neuropathy in the upper extremity.[17] Dellon compared the pain and 2-point discrimination before- and after surgery,[17] whereas in our study, we compared pain, HT, MF (MF), numbness, and tingling. In our study, patients with idiopathic PNP showed significant improvements in HT, MF, and numbness. Although pain and tingling improved in clinical examination, this improvement was not significant. One possible reason for this result could be the relatively small number of patients with idiopathic PNP in our study. Patients with a diabetic PNP significantly improved in all of the examined qualities.

If it is assumed that nerve damage in patients with diabetic PNP is caused by a double-crush phenomenon involving, on the one hand, direct external pressure on the nerve exerted by an anatomically existing structure (flexor retinaculum at the ankle) and, on the other, by



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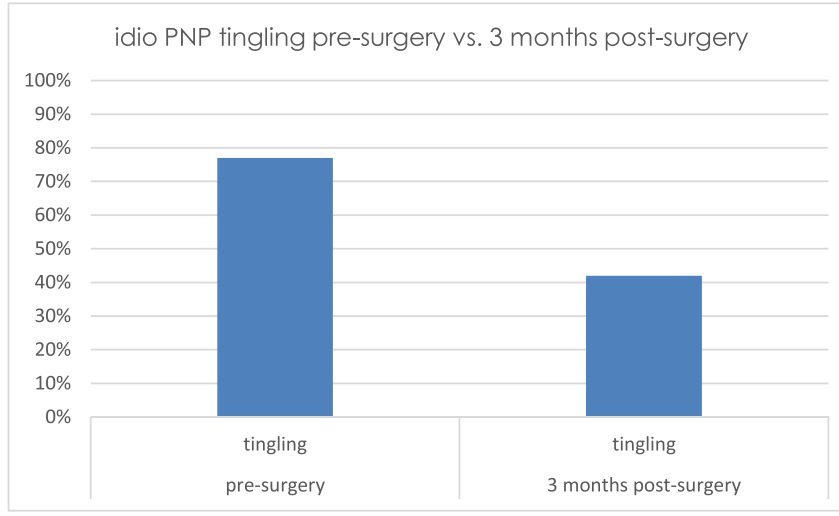

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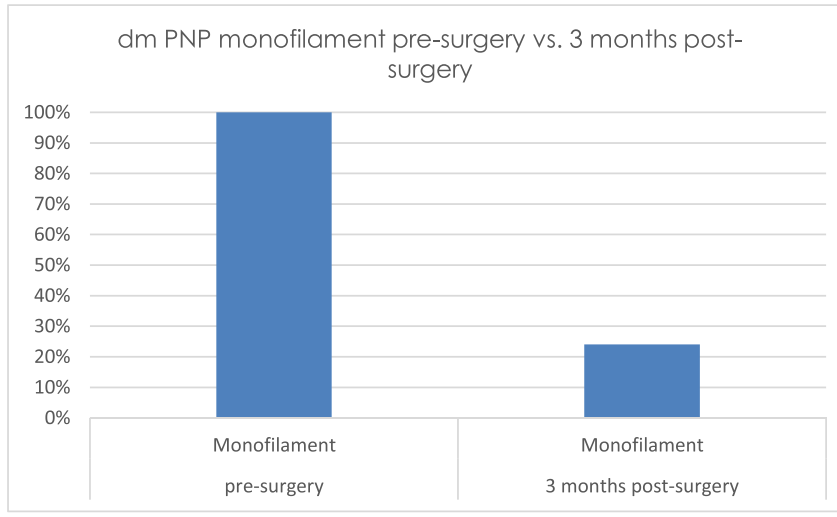
FIGURE 7. A, Comparison of tingling sensations in patients with diabetic PNP before surgery (90% of patients complained before surgery about tingling in the legs) and 3 months after surgery (18% of patients complained after surgery about tingling in the legs). $P = 0.000$. B, Comparison of tingling sensations in patients with idiopathic PNP before surgery (77% of patients complained before surgery about tingling in the legs) and 3 months after surgery (42% of patients complained after surgery about tingling in the legs). $P = 0.111$.

intraneural edemas, and that these edemas do not play any role in patients with idiopathic PNP, it makes sense in our opinion that patients with diabetic PNP will benefit more from nerve decompression surgery than patients with idiopathic PNP. We postulate that the very swollen nerves due to edemas in patients with diabetic PNP profit more from this surgical relief of the mechanical obstacle than patients with idiopathic PNP, in whom the nerves tend not to be as swollen, meaning that the degree of relief after removal of the mechanical obstacle is not as great or is not subjectively perceived by the patient to be as great.

The advantage of our study is that we investigated in a retrospective study design the effectiveness of surgical decompression of the lower extremity not only in patients with diabetic PNP but also in patients with idiopathic PNP. Triple-nerve decompression of the lower extremity proved to be an effective treatment, not only decreasing the pain suffered by patients with PNP but also improving lower extremity sensation and thereby increasing the patients' quality of life. In our study, it was not only pain but also the sensory disorder in the lower extremity that was the main complaint and the reason for the operation. Improving sensation in the lower extremity increases balance and walking stability. Polyneuropathy impairs the ability of patients to stabilize their body when walking on uneven surfaces, even if they adopt a more conservative gait pattern.[26]

Menz et al[26] were able to demonstrate in their work that peripheral sensitivity plays a very important role in controlling gait stability. They suspect that a sensory disorder in the lower extremity/sole of the feet is one factor that increases the risk of falls in older patients with diabetic PNP.

Loss of protection sensation in PNP leads to repeated foot injury, ulceration, and ultimately amputation. Decompression of peripheral nerves in diabetic peripheral neuropathy seems to be a good treatment



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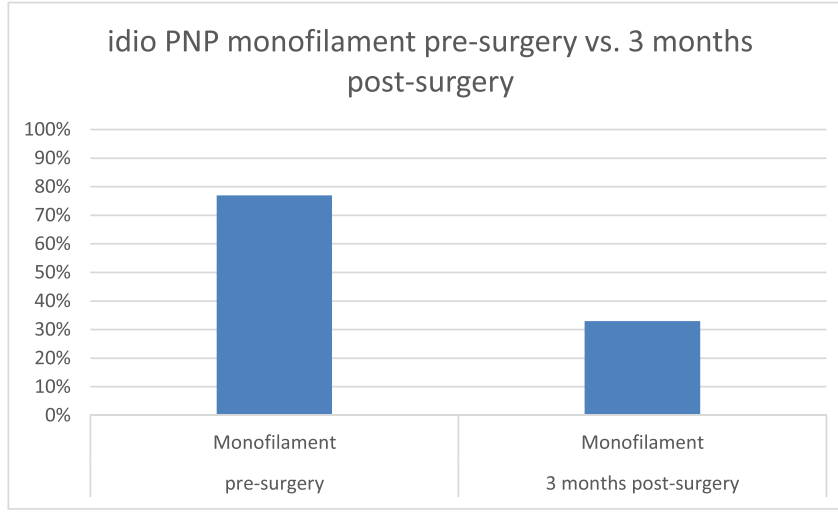

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FIGURE 8. A, Comparison of the MF test in patients with diabetic PNP: before surgery, 100% of patients had a negative MF test result in the legs; that is, none of the patients were able to correctly identify the MF presurgery. Three months after surgery, only 24% of the patients still had a negative MF test result in the legs. $P = 0.000$. B, Comparison of the MF test in patients with idiopathic PNP before surgery (77% of patients had a negative MF test result in the legs before surgery) and 3 months after surgery (33% of patients had a negative MF test result in the legs after surgery). $P = 0.047$.

option for restoring sensation, decreasing pain, and avoiding the development and recurrence of ulceration and amputation. This therapy concept of nerve decompression in the lower extremity of patients with PNP thus leads also to a significant reduction of the costs of treating these patients.[27]

We were able to show that this concept applies also to patients with idiopathic PNP (Table 2).

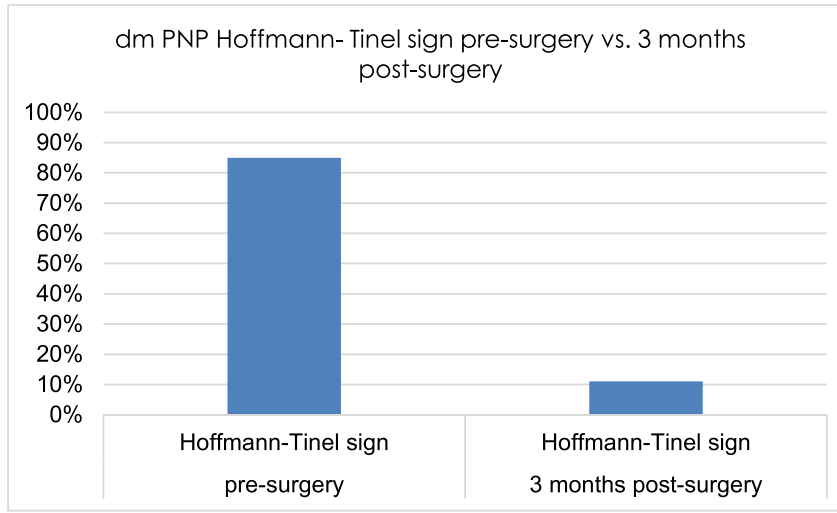
Limitations

We were able to examine 29 of 33 patients for this study. Although this is a relatively small number, it is nonetheless sufficient for a very special indication, given that the concept of nerve decompression in the lower extremity is still not very popular among neurologists. Another drawback of our study is the fact that we were only able to follow up our patients for 3 months after surgery. However, because most patients report an improvement in their symptoms immediately after the operation,[18] our data with short-term results confirm that nerve decompression makes sense for patients with diabetic and idiopathic PNP.

CONCLUSIONS

Nerve decompression of the lower extremities is a good surgical means of improving symptoms such as pain, numbness, tingling, and sensory disorders in selected patients with idiopathic or diabetic PNP.

We hope that this work will contribute to this surgical method gaining further in popularity, thereby allowing more affected patients to benefit from nerve decompression surgery. To this end, it is important for a center's neurologists and plastic surgeons to work closely together.



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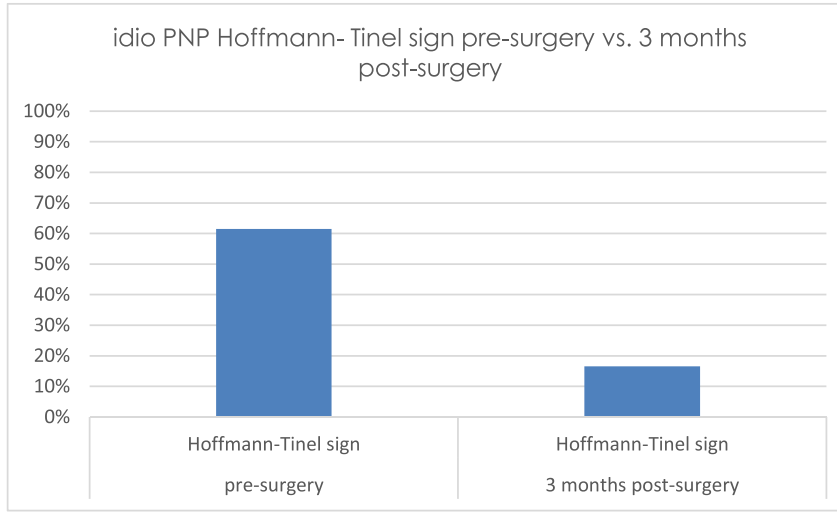

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FIGURE 9. A, Comparison of positive HT sign in the lower extremity in patients with diabetic PNP before surgery (85%) and 3 months after surgery (11%). *P* = 0.000. B, Comparison of positive HT sign in the lower extremity in patients with idiopathic PNP before surgery (62%) and 3 months after surgery (17%). *P* = 0.041.

TABLE 1. Representative Cases From Our Study

			Typ of PNP			Outcome									
						HT		MF		Tingling		Numbness		Pain	
Pat. Nr.	Age, y	Sex	Idio	d.m.	FU, mo	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
23	73	f		1	3	1	2	2	1	2	2	1	2	9	4
19	75	m	1		3	2	2	2	2	2	2	1	2	8	0

Two representative cases from our study. 2 = negative 1 = positive.

d.m.; diabetic PNP, f, female; FU, follow-up; Idio., idiopathic PNP; m, male; Pat. Nr., patient number; pre, before surgery; post, after surgery.

TABLE 2. Patients' Details and Procedure, Follow-Up, and Outcomes

			Typ of PNP			Outcome									
						HT		MF		Tingling		Numbness		Pain	
Pat. Nr.	Age, y	Sex	Idio	d.m.	FU, mo	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	69	m		1	3	1	1	2	1	1	1	1	2	9	6
2	58	m		1	3	1	2	2	1	1	2	1	2	0	0
3	60	m		1	3	1		2		1		1		0	
4	89	f		1	3	1	2	2	2	1	2	1	1	1	0
5	78	m		1	3	1	2	2	1	1	1	1	1	3	0
6	76	m		1	3	**1**	2	2	2	1	2	1	2	5	0
7	78	f		1	3	1	2	2	1	1	2	1	2	0	0
8	77	m		1	3	2	2	2	2	1	1	1	1	0	0
9	47	m		1	3	1	2	2	1	1	2	1	2	0	0
10	66	m	1		3	1	1	1	1	1	1	1	1	5	7
11	65	m	1		3	1	2	2	1	1	2	1	1	0	0
12	72	f		1	3	1	2	2	2	1	2	1	1	6	1
13	70	m		1	3	1	2	2	1	1	2	1	1	10	5
14	68	m		1	3	2	1	2	1	2	2	1	2	0	0
15	60	f	1		3	2	1	2	1	1	2	1	2	0	0
16	80	f	1		3	2	2	2	2	1	1	1	1	8	2
17	49	f	1		3	2	2	2	1	1	1	1	1	7	4
18	86	m	1		3	1	2	2	1	2	2	2	2	7	0
19	75	m	1		3	2	2	2	2	2	2	1	2	8	0
20	77	m	1		3	1	2	2	2	1	1	1	1	9	9
21	84	f	1		3	2	2	2	1	1	2	1	2	6	4
22	84	m		1	3	1	2	2	1	1	2	1	1	7	5
23	73	f		1	3	1	2	2	1	2	2	1	2	9	4
24	71	m		1	3	2		2		1		1		10	
25	66	m		1	3	1		2		1		1		8	
26	90	f		1	3	1	2	2	1	1	2	1	2	7	0
27	76	m	1		3	1	2	2	2	1	1	1	1	0	0
28	62	m	1		3	1		1		2		1		0	
29	65	m		1	3	1	2	2	1	1	2	1	2	8	8
30	53	m		1	3	1	2	2	1	1	2	1	1	6	6
31	53	m	1		3	1	2	1	1	1	2	1	2	0	0
32	70	m	1		3	1	2	2	1	1	2	1	2	0	0
33	62	m		1	3	1	2	2	1	1	2	1	2	10	0

Procedure: all patients underwent triple-nerve decompression at the common peroneal nerve, tibial nerve, and deep peroneal nerve. HT sign: 1 = positive, 2 = negative. MF: 1 = positive, 2 = negative (the test was positive if patients responded "yes" each time they felt the prick of the MF). Tingling and numbness: 1 = yes, 2 = no.

d.m., diabetic PNP; f, female; FU, follow-up; idio = idiopathic PNP; m, male; pre, before surgery; post, after surgery.

Once all conservative treatment options have been exhausted, we offer this surgery to patients with diabetic or idiopathic PNP after carefully explaining all the potential risks and benefits of surgery to them.

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