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Original Article

Schwannomas of the peroneal nerves: Clinical and functional results of surgical treatment

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Abstract

Objectives: Peroneal nerves Schwannomas are rare benign tumors. Literature is still poor of studies about clinical and functional outcomes after surgical treatment. We evaluated the pre-operative presentation of the disease and assessed clinical and functional outcomes after surgery. **Methods**: We collected all the cases of peroneal nerves' neurinoma treated surgically between June 2016 and June 2020. We analyzed each patients' personal data and carried out accurate clinical examinations before and after surgery. MRI was performed both pre-operatively and post-operatively. **Results**: We reported 9 cases of peroneal nerves schwannomas: five arising from the common peroneal nerve and four arising from the deep or superficial branches alone. Their mean size was 22.6 mm. Each patient showed sensation deficits before surgery; pre-operative MRC score was 4.2. Pre-Operative MSTS and LEFS scores were 23.6 and 64.4. Surgery was successful in each case. No local recurrence nor major complication occurred. Tumor size was significantly associated with both diagnostic delay and development of pre-operative deficits. Surgery was proven to be globally successful: post-operative evaluations highlighted a marked reduction of neurological signs and overall functional limitations. **Conclusions**: Surgical treatment at early stages of the disease represents a reliable and relatively safe therapeutic option.

Keywords: Functionality, Lower Limb, Neurinoma, Peroneal nerves, Schwannoma

Introduction

Schwannomas, less commonly known as neurinomas or neurilemmomas, are the most frequent benign tumors to arise from peripheral nerves.

Peroneal nerves Schwannomas can remain clinically silent for a long period of time, until local mass effect eventually causes symptoms such as dysesthesia, pain and muscle strength deficiency[1,2].

Their growth is often slow but unceasing and masses easily reach remarkable dimensions if a proper therapy is not undertaken. While a conservative approach may be suitable for small sized tumors, wider lesions require a proper therapy. Drug therapy does not represent a reliable option to affect the natural history of solitary schwannomas, although analgesics and neurotrophic drugs might play a role in reducing the entity of pain and neurological deficits. To this date direct surgical approaches represent the only way to eradicate the tumor.

Despite minimally invasive approaches, such as percutaneous cryoablation, have been described[3], open surgery represents the consensus treatment of choice. Excision of the mass aims to decompress the affected nerve, whether it be intracapsular or extracapsular. In most cases even marginal excision can be curative and result in symptoms relief; moreover, intracapsular excision is thought to be a better method to preserve nerve function[4-6].

Schwannomas of the peroneal nerves are rare and poorly reported in literature, with little focus on functional outcomes[7-9]. The goal of this study was to report surgical management in a case series of 9 patients treated for peroneal nerve schwannomas and evaluate their functional status before and after treatment in a mid-term follow up.

The authors have no conflict of interest.

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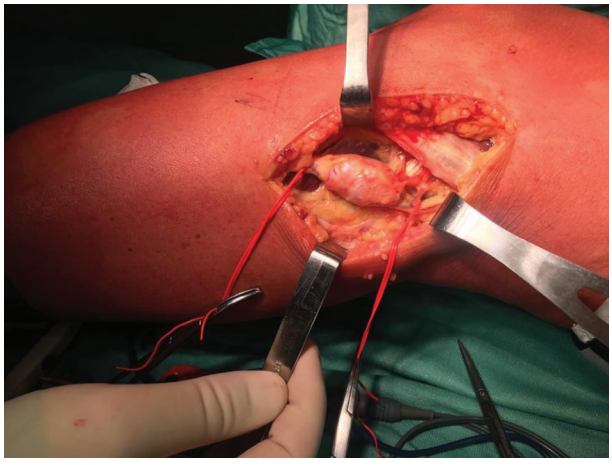

Figure 1. Intra-operative image of an exposed schwannoma grown from the common peroneal nerve.

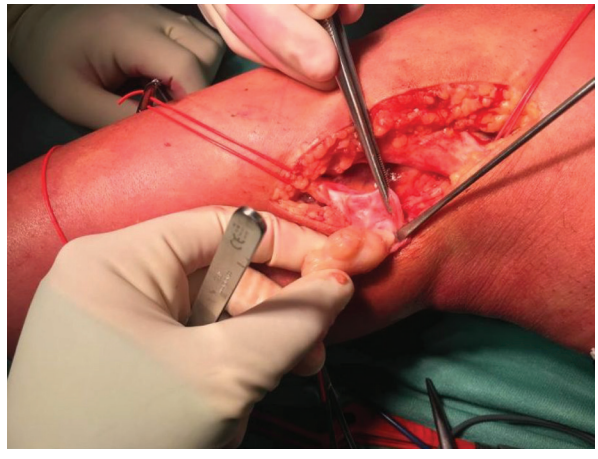

Figure 2. Enucleation of a common peroneal nerve schwannoma.

Materials and methods

This single-center retrospective study was approved by our local ethics committee and performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Our study consisted of a review of all schwannomas of the peroneal nerves treated with surgery in our institution between June 2016 and June 2020.

For each patient we collected data regarding their age, gender, first symptom associated with the disease and its date, alongside with the date in which schwannoma was diagnosed. We reviewed the date and the type of surgery performed. Pre-operative and post-operative functional status of our patients was evaluated using both the Lower Extremity Functional Scale (LEFS) score and the Musculoskeletal Tumor Society (MSTS) score respectively at the moment of hospitalization before surgery and at their last follow up. Muscular strength was assessed before and after surgery using the Medical Research Council (MRC) scale for muscle strength[10-12]. In parallel, Tinel test and a careful examination of the deep and cutaneous sensitivity were practiced to every patient with suspect of neurinoma before their intervention and were repeated at patient's latest follow-up[13]. Each patient underwent pre-operative MRI, which was used to orientate the diagnosis, guide the surgical planning and estimate the tumor size. Each neoplasm resected was examined by a pathologist to confirm the diagnosis of schwannoma with routine histology, histochemistry and immunohistochemistry techniques.

Postoperative follow-up consisted of serial office visits, clinical evaluations and post-operative MRIs. Each complication with grade II or higher according to the Clavien - Dindo Classification were reported[14].

Statistical Analysis

Statistical analysis was performed using Stata SE 13 (StataCorp LLC, College Station, TX). Statistical significance was set at 0.05 for all endpoints.

Results

9 patients underwent surgery to treat schwannomas of the peroneal nerves in our institution between June 2016 and June 2020. In 5 of these cases the neoplasm involved the common peroneal nerve, while the other 4 the process involved its terminal branches: the superficial peroneal nerve (3 cases) or the deep peroneal nerve. They were 6 females and 3 males, with a mean age at surgery of 55.7 (21-84) years.

In none of our cases diagnosis was incidental, since every case was brought to medical attentions by the onset of symptoms attributable to the disease. The first symptom referred was paresthesia in 6 cases (66.7%), a palpable swelling in 2 cases (22.2%) and reduced muscle strength in 1 case (11.1%). On average, diagnosis was made 6.6 (1-12) months after the onset of the first symptom.

According to pre-operative MRI images, the mean tumor dimension considering its major axis, was 26.6 (11-39) mm.

Before surgery, each of our 9 patients developed at least one neurologic symptom. Paresthesia was developed in 8 cases (88.8%): its entity was mild in 2 cases (22.2%), moderate in 5 (55.5%) and severe in the remaining 2 (22.2%). The Hoffman - Tinel sign was strongly positive in 7 of our 9 patients (77.7%), while in the other 2 (22.2%) it was weakly positive.

Pre-operative muscular strength of the anterior and lateral muscular compartment of the leg was evaluated and classified using the MRC scoring scale. The mean pre-operative MRC score was 4.2 (2-5), with only 4 of our 9

Table 1. Pre-operative picture of our case series.

N	AGE (y)	SITE	DIAGN. DELAY (m)	SIZE (mm)	FIRST SYMPTOM	PreOp TINEL	PreOp SENSITIVE DEFICIT	PreOp MRC (/5)	PreOp MSTS (/30)	PreOp LEFS (/80)
1	39	Common Peroneal N.	11	20	Paraesthesia	+	Moderate	5	25	70
2	72	Common Peroneal N	3	30	Tumefaction	+/-	Moderate	5	26	72
3	54	Common Peroneal N.	12	42	Paraesthesia	+	Moderate	4	24	66
4	48	Common Peroneal N.	5	25	Paraesthesia	+	Moderate	4	23	67
5	44	Common Peroneal N.	9	39	Weakness	+	Severe	3	18	47
6	84	Deep Peroneal N.	10	36	Paraesthesia	+	Severe	2	15	34
7	65	Superficial Peroneal N.	5	25	Tumefaction	+	Moderate	5	24	71
8	74	Superficial Peroneal N.	1	11	Paraesthesia	+/-	Mild	5	28	76
9	21	Superficial Peroneal N.	3	11	Paraesthesia	+	Mild	5	29	77

Table 2. Comparison between pre-operative conditions and post-operative outcomes.

N	SITE	SIZE (mm)	PreOp TINEL	PreOp SENSITIVE DEFICIT	PreOp MRC (/5)	PreOp MSTS (/30)	PreOp LEFS (/80)	PostOp TINEL	PostOp SENSITIVE DEFICIT	PostOp MRC (/5)	PostOp MSTS (/30)	PostOp LEFS (/80)	FU (m)
1	CPN	20	+	Moderate	5	25	70	-	-	5	30	79	57
2	CPN	30	+/-	Moderate	5	26	72	-	-	5	30	80	36
3	CPN	42	+	Moderate	4	24	66	-	-	5	30	80	16
4	CPN	25	+	Moderate	4	23	67	-	-	5	29	79	26
5	CPN	39	+	Severe	3	18	47	+/-	Moderate	4	27	64	9
6	DPN	36	+	Severe	2	15	34	+/-	Moderate	3	23	61	12
7	SPN	25	+	Moderate	5	24	71	-	-	5	30	80	14
8	SPN	11	+/-	Mild	5	28	76	-	-	5	30	80	20
9	SPN	11	+	Mild	5	29	77	-	-	5	30	80	16

CPN= Common Peroneal Nerve, DPN = Deep Peroneal Nerve, SPN = Superficial Peroneal Nerve.

cases that suffered an at least partial reduction of muscular strength (see Table 1).

Overall pre-operative functionality was assessed using the MSTS Score for lower limbs and the LEFS score, whose mean values were respectively 23.6 (15-29) and 64.4 (34-77) (Table 1).

An overview of patients' pre-operative neurological status and clinical presentation is reported in detail in Table 1.

All our cases underwent complete excision of the neoplasm; none of them required intralesional excision (Figure 1 and Figure 2). One of our cases (case 6) needed partial nerve repair using a neurotube. None suffered from major complications during surgery or through the post-operative course.

The mean follow-up was 22.9 (9-57) months. None of our cases developed local recurrence nor major complications through the follow-up (grade II or higher according to the Clavien - Dindo classification). All of our patients were treated with oral integration of lipoic acid, citicoline and vitamins B for 30 days after surgery in order to obtain an antioxidant, neurotrophic and neuroprotective effect.

6 of our 9 cases (66.6%) did not complain of paresthesia through their whole post-operative course. Among the 3 that reported episodes of paresthesia in the weeks or months that followed surgery, one (11.1%) had episodic symptoms that solved within 5 weeks, while the other 2 (22.2%) still suffered moderate paresthesia at their last clinical control. Slightly positive Hoffman-Tinel sign persisted in only one case. Compared to the pre-operative findings, each patient reported a reduction of their sensitive symptoms after the intervention.

Post-operative muscular strength was 5/5 in 7 cases (77.7%), 4/5 (11.1%) in one case and 3/5 (11.1%) in one other. The mean post-operative MRC score was therefore 4.6 (3-5), a value 0.4 higher compared to the pre-operative one. All the cases with a preoperative muscular strength impairment

(MRC<5) benefited the removal of the schwannoma, gaining 1 point in their post-operative MRC score.

At the latest follow-up the mean MSTS score was 28.8 (23-30), a value 5.2 (1-9) higher than the mean pre-operative score. The mean post-operative LEFS score was 75.9 (61-80), 11.4 higher than the pre-operative one. According to the paired one-tailed t-student test, the reduction of the mean values of both MSTS (p=0.0003) and LEFS (p=0.0158) after surgery were statistically significant. The two scores testified an at least slight increasement of each patient's lower limb functionality.

Clinical and functional results of our population are summarized in Table 2.

Statistical analysis defined a significant positive correlation between diagnostic delay and tumor size at the moment of procedure (r=0.6952; p=0.0376). Neoplastic mass dimension, for its part, had a significantly negative correlation with patients' pre-operative MRC scores (r= -0.6778; p=0.0452), MSTS scores (r=-0.7298; p=0.0258) and LEFS scores (r=0.6739; p=0.0465).

Tumor size also showed a positive correlation with post-operative functional recovery assessed with both the differential MSTS score (r=0.8356; p=0.0050) and LEFS score (r=0.7672; p=0.0158). The differential between pre-operative and post-operative LEFS scores also had a statistically significant correlation with patients' diagnostic delay (r=0.6675; p=0.0495). Surgery significantly decreased the prevalence of Hoffmann-Tinel test (p=0.0152).

Discussion

Neurilemmomas (schwannomas - neurinomas) of the peroneal nerves are rare benign tumors which arise from active Schwann cells that form myelin around peripheral nerves. They usually have an internal homogeneous structure and a peripheral capsule that separates them from the surrounding tissues and the native nerve. In general, they show no tendency to infiltration of the nearby structures and generally show a slow but progressive local growth. Only 1% of all schwannomas tend to transform into neurofibrosarcoma or malignant schwannoma.

Although they can stay clinically silent even for months or years, symptoms and signs may arise as the volume of the tumor increases, exerting an increasing pressure and compression on the nerve and the adjacent structures. Symptoms therefore appear with various combinations of pain, swelling and alteration of neuromotor or sensitive neurological functionality.

Particularly in nerves with superficial course, like the common and the superficial peroneal nerves, neoplasms can be identified visibly and to the touch as a round or ovoid swelling, painful to pressure and mobile side to side, but not in the vertical axis of the limb[15]. Percussion of the mass usually induces painful paresthesia in the regions innervated by the nerve of origin, defined as Hoffman-Tinel sign. 7 an 2 of our 9 patients (77.7% and 22.2%) resulted respectively strongly and slightly positive at their Tinel test. Those results in line with the ones described by Knight et al who reported an incidence of 81% in their population of benign schwannomas in different body districts[15]. Progressive neurological deficits occur primarily in those tumors that take place in confined spaces, like those that lodge the peroneal nerves.

Schwannomas that arise from the deep peroneal nerve, in particular, can be compressed by the overlaying firm fascia of the anterior compartment of the leg, with consequential severe pain and motor deficits. This eventuality, already described by Sharma et al in their case report in 2000[16], was also reported by our only patient suffering from a schwannoma of the deep peroneal nerve, case 6, who had developed serious sensitive and mobility deficits and had the lowest pre-operative and post-operative functional scores among our population.

As already described in literature[17-18], enucleation or excision were largely possible in the vast majority of cases, with little or no damage inflicted to the underlying nerve fascicles in 8 of our 9 cases. In the remaining case, a graft was used to repair the partial damage done to the nerve during resection. The absence of major intra-operative or post-operative complications in our study testifies the relative safety and reliability of the surgical procedures. However, surgeons should be aware that peroneal nerve injuries following surgical treatments are not uncommon as already described in literature[17].

Our data suggest the effectiveness of the surgical treatment in reducing both sensitive and strength deficits and increasing the overall lower limb's functionality. At the last follow-up, only 2 patients (22.2%), case 5 and 6, had sensitive deficits of moderate entity and reduced muscular strength, with respectively grades 3 and 4 according to the MRC scoring system. The other 7 patients (77.7%) could reach a complete or nearly complete resolution of any sign or symptom caused by the tumor. Our outcomes can be considered to be consistent with the previous studies in literature for lower limb schwannomas, although they did not treat specifically the ones involving the peroneal nerves[15,17].

All our patients had better post-operative functionality compared to their pre-operative conditions, assessed with both the MSTS score and the LEFS score. The combination of high overall post-operative outcomes according to the aforementioned scoring systems (MSTS=28.8 and LEFS=75.9), both significantly increased after surgery, testifies the effectiveness of our treatment.

In literature some authors found that the risk of developing neurological deficits - and therefore a drop of patients' lower limb functionality and quality of life - was directly associated with the tumor size: as the dimension of the tumor increases, so does the risk it may cause significant neurological signs or symptoms[17,19-21]. Our results corroborate this hypothesis, since in our population tumor dimensions were inversely proportional to pre-operative muscle strength, assessed with the MRC score (r=-0.6778; p=0.0452), and lower limb functionality, estimated with both the MSTS (r=-0.7298; p=0.0258) and the LEFS (r=0.6739; p=0.0465) scoring

system. In addition, larger schwannomas where the ones that reported the more evident functional recoveries after surgery, as a link between tumor diameter and both the differential MSTS score (r=0.8356; p=0.0050) and LEFS score (r=0.7672; p=0.0158) emerged. Our population therefore suggests the importance and the effectiveness of the surgical treatment for peroneal nerves' neurinomas. The length of the period between the onset of symptoms and the proper diagnosis was significantly associated with tumor size itself. These evidences lead us to believe that an early diagnosis could be crucial to prevent the onset or the worsening of symptoms that could reduce patients' functionality and quality of life, allowing surgeons to eradicate the tumor at the down of its clinical presentation.

We acknowledge our study had some limitations. The rarity of these tumors did not allow us to operate on a wide population, which partially limited the statistical significance of some of the data associations we wanted to investigate at the beginning of our research. Another limitation is represented by the retrospective nature of our study, which did not allow the complete standardization of the post-operative follow-up procedures for each patient.

Beyond these limits, our encouraging findings could play their part in expanding the knowledge on a topic like the schwannomas of the peroneal nerves that was relatively untouched in previous literature. Our focus and our findings were not confined to factors of surgical interest such as post-operative complications, local recurrence or presentation of pain and other symptoms before and after the treatment. We extended our research on the functional sphere, which might be compromised by lower limb schwannomas, proving that a correct surgical excision can partially or even solve functional impairment, therefore increasing patients' quality of life.

In conclusion, peroneal nerves' neurinomas are extremely rare benign tumors which may present with a peculiar combination of neurological deficits in association with a localized swelling. The combination of signs and symptoms associated with these lesions that can be responsible for reduced functionality of the involved lower limb. Surgical excision, especially if practiced by expert operators, represents a reliable therapeutic approach that could reduce the neurological deficits and potentially restore the complete functionality of the nerve from which schwannoma arises.

Consent to participate

All patients gave their written consent to every part of their therapeutic and evaluation process. Each patient had been fully informed about each possible therapeutic strategy, with pros and cons of each possible approach.

Consent to publish

Consent to publication and to the use of each data was given by each participant.

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