OPEN ACCESS

Original Article

Submitted: 26-04-2024
Accepted: 12-08-2024

DOI: https://doi.org/10.52783/jns.v13.1437

A Rare Case of Schwannoma in the Lateral Sural Cutaneous Nerve: Diagnosis, Surgical Intervention, and Clinical Outcomes

Dr. Vidhyadhar Wadkar[1], Dr. PN Kulkarni[2]

[1]Department of Orthopaedics, Krishna Institute of Medical Sciences,Krishna Vishwa Vidyapeeth, "Deemed To Be University", Karad,Malkapur, Karad (Dist. Satara), Maharashtra, India. PIN – 415539.
vidhyadharw@gmail.com

[2]Professor, Department of Orthopaedics, Krishna Institute of Medical Sciences, Krishna Vishwa Vidyapeeth, Deemed To Be University", Karad, Malkapur, Karad (Dist. Satara), Maharashtra, India. PIN – 415539.
drpnkulkarni@yahoo.co.in

KEYWORDS

schwannoma, lateral sural cutaneous nerve, peripheral nerve sheath tumor, MRI, surgical enucleation, lower extremity tumor

ABSTRACT

Peripheral nerve sheath tumors (PNSTs) are uncommon, with schwannomas being the most frequent benign variant. These tumors, composed solely of Schwann cells, typically arise in the head, neck, or upper extremities, making their occurrence in the lower limbs, especially in the sural nerve, extremely rare. This case report documents a schwannoma in the lateral sural cutaneous nerve of a 51-year-old female presenting with pain and swelling in the right ankle. Diagnostic imaging with MRI revealed a well-defined, encapsulated mass with characteristic features of schwannoma, confirmed through histopathology. Surgical excision using microscopic enucleation was performed, preserving nerve function and resulting in complete symptom relief. Postoperative follow-up showed no recurrence or neurological deficits. This case highlights the importance of considering schwannomas in differential diagnoses of lower limb masses and demonstrates that precise surgical intervention can yield excellent outcomes.

I. Introduction

Peripheral nerve sheath tumors (PNSTs) are a rare group of neoplasms arising from the cells that form the protective covering of peripheral nerves. These tumors are generally benign but have the potential for malignant transformation. Among the benign variants, schwannomas and neurofibromas are the most common, each with distinctive histological characteristics and clinical manifestations. Schwannomas, specifically, are encapsulated tumors that originate from Schwann cells—the glial cells responsible for the formation of the myelin sheath around peripheral nerve fibers. Unlike neurofibromas, schwannomas are often isolated, encapsulated masses that grow slowly and typically remain asymptomatic until they reach a size large enough to compress surrounding structures [1]. Schwannomas, also known as neurilemmomas, account for approximately 8% of all soft tissue tumors and about 5% of benign tumors found in the head, neck, and extremities. These tumors are unique in that they arise solely from Schwann cells, unlike neurofibromas, which contain a mix of cellular elements and involve the entire nerve. Schwannomas are usually solitary, well-circumscribed, and encapsulated, allowing them to be surgically removed without damaging the underlying nerve in most cases. Histologically, they exhibit two distinct patterns: Antoni A areas, which are dense, cellular areas with spindle-shaped cells arranged in a palisade formation, and Antoni B areas, which are loosely organized and have a myxoid, less cellular structure.

Schwannomas can develop anywhere in the body, though they are most commonly located in the cranial nerves, particularly the vestibular nerve, where they are known as vestibular schwannomas or acoustic neuromas. In the peripheral nervous system, they more frequently affect the brachial plexus and the nerves in the upper extremities. However, their occurrence in the lower extremities, specifically in the sural nerve, is exceedingly rare [2]. The rarity of schwannomas in the lower extremities, particularly in the sural nerve, can be attributed to the fact that this nerve has less Schwann cell activity compared to other nerve structures like the brachial plexus or cranial nerves. The sural nerve is a sensory nerve that supplies sensation to the lateral ankle and foot, arising from the union of branches of the tibial and common peroneal nerves. Schwannomas in this region are typically solitary and asymptomatic, but they can become painful or produce neurological symptoms as they enlarge and compress adjacent tissues.

The presence of a schwannoma in the lower limb presents unique diagnostic and therapeutic challenges due to its rarity and often nonspecific symptoms, such as localized pain or swelling. Additionally, differential

diagnosis in these cases is broad and includes other soft tissue masses like lipomas, ganglion cysts, and other neurogenic tumors, which can complicate the identification of schwannomas without detailed imaging and histopathological examination [3]. A lack of awareness among clinicians can lead to misdiagnosis or delayed diagnosis, as symptoms are often initially attributed to more common conditions like tendinitis, bursitis, or other benign masses. The diagnosis of schwannoma is typically confirmed through imaging modalities and histopathological examination. Magnetic resonance imaging (MRI) is the preferred imaging technique for evaluating soft tissue masses like schwannomas. On MRI, schwannomas display distinct characteristics, often appearing isointense to hypointense on T1-weighted images and hyperintense on T2-weighted images, with a target-like appearance. The "target sign," a characteristic MRI feature, is seen in many schwannomas and represents a well-defined mass with a hypointense center and hyperintense periphery on T2-weighted images. Ultrasonography can also be useful, often revealing a well-defined, homogeneous hypoechoic mass that can assist in identifying the nerve of origin.

A definitive diagnosis requires histopathological confirmation, where the classic Antoni A and Antoni B regions become visible. Immunohistochemical staining for S-100 protein, which is expressed in Schwann cells, can further confirm the diagnosis, as this marker is highly sensitive for schwannomas. Other markers, like CD34, can help distinguish schwannomas from neurofibromas and other soft tissue tumors. Clinically, patients with schwannomas in the lower extremities may present with a variety of symptoms depending on the tumor's size and location. Smaller tumors may be asymptomatic and discovered incidentally [4], while larger masses may cause pain, a palpable mass, or neurological deficits due to nerve compression. In cases involving the sural nerve, patients may experience localized pain or paresthesia in the distribution area of the nerve, which includes the lateral aspect of the foot and ankle. Neurological symptoms, if present, are typically sensory, as the sural nerve is primarily a sensory nerve with limited motor function.

The treatment of choice for schwannomas is complete surgical excision, ideally through a technique called "microscopic enucleation," which allows the surgeon to remove the tumor while preserving the integrity of the nerve. In cases involving the sural nerve, microscopic enucleation has shown excellent outcomes with minimal risk of postoperative neurological deficits. The encapsulated nature of schwannomas makes them amenable to surgical resection, as the tumor can usually be separated from the surrounding nerve fibers without damaging the functional fascicles. Postoperative outcomes are generally favorable, with a high rate of symptom relief and a low risk of recurrence. Given the rarity of schwannomas in the lower extremities, they are often mistaken for more common types of soft tissue masses [5]. A limited number of differential diagnoses exist for a solitary swelling on the posterior aspect of the leg, including lipomas, ganglion cysts, neuromas, and neurofibromas. Neurofibromas, for example, are similar in that they are also benign nerve sheath tumors; however, they tend to infiltrate the nerve rather than remain encapsulated, making surgical excision more challenging. Additionally, unlike schwannomas, neurofibromas are often associated with neurofibromatosis type 1 (NF1), a genetic disorder characterized by multiple neurofibromas and other systemic manifestations.

Schwannomas are usually sporadic, though they may be associated with certain genetic conditions like neurofibromatosis type 2 (NF2) in rare cases. Unlike neurofibromas, schwannomas are not typically linked to NF1, which is important in the differential diagnosis process. The sporadic occurrence of schwannomas and their distinct encapsulation allow for easier surgical management, whereas neurofibromas often require more extensive procedures and may lead to nerve damage due to their infiltrative nature.

II. Background

Peripheral nerve sheath tumors (PNSTs) encompass a range of neoplasms originating from the supportive tissue surrounding peripheral nerves, with the majority being benign. Among these, schwannomas and neurofibromas are the most common. Schwannomas, also known as neurilemmomas, are benign tumors composed entirely of Schwann cells, which produce the myelin sheath essential for nerve signal transmission. They are typically encapsulated, well-defined, and slow-growing, often arising as solitary masses in nerves. Schwannomas frequently develop in the cranial nerves and upper extremities [6][7], but their occurrence in the lower extremities, specifically in the sural nerve, is exceedingly rare. The sural nerve, which provides sensory innervation to the lateral ankle and foot, is formed by branches from the tibial and common peroneal nerves. Schwannomas in this region are unique due to their rarity, often leading to delayed diagnosis and treatment as clinicians may not initially consider a nerve sheath tumor in cases of lower limb masses.

Schwannomas are frequently asymptomatic until they grow large enough to compress surrounding tissues, causing symptoms such as localized pain, swelling, or sensory disturbances. Diagnosing schwannomas in atypical locations like the lower extremity requires a comprehensive clinical evaluation and imaging studies, particularly MRI, which helps delineate the tumor and distinguish it from other soft tissue masses [8][9][10]. Treatment generally involves surgical excision, ideally preserving the nerve and reducing the risk of recurrence. This case report adds to the limited literature on schwannomas in the sural nerve, highlighting the clinical features, diagnostic approach,

and surgical outcomes associated with this rare presentation.

Aim and Objective

Aim: To present a rare case of schwannoma originating from the lateral sural cutaneous nerve in a patient with localized pain and swelling in the lower extremity, emphasizing diagnostic challenges and surgical management.

Objective:

1. To document the clinical presentation of a sural nerve schwannoma and the associated symptoms.

2. To detail the diagnostic process, including clinical examination and imaging, used to accurately identify this rare tumor.

3. To describe the surgical approach and outcomes, providing insights for managing similar cases.

4. To highlight the importance of considering schwannomas in the differential diagnosis of solitary masses in the lower extremity.

This study aims to support clinicians in recognizing, diagnosing, and treating rare nerve sheath tumors in atypical locations, potentially improving patient outcomes through early intervention.

III. Material and Methods

Patient Presentation

A 51-year-old female presented to the orthopedic outpatient department with a two-year history of localized pain and swelling on the posterolateral aspect of her right ankle. The patient described the pain as dull and aching, exacerbated by physical activity and relieved with rest and non-steroidal anti-inflammatory drugs (NSAIDs). Initially misdiagnosed as a calcaneal spur, the swelling had shown a gradual increase in size over the two years, prompting further evaluation at our center.

On physical examination, a well-defined, spherical mass approximately 3 x 3 cm in size was palpable on the distal third of the right leg, just above the lateral malleolus. The mass was soft, non-pulsatile, and non-fluctuant, with mild tenderness upon palpation. The overlying skin appeared normal, without signs of erythema or discharge, and no motor or sensory deficits were identified below the swelling. The mass was also immobile, suggesting a deep-seated origin likely associated with underlying neural structures. There were no other similar swellings noted elsewhere on the patient's body, and no history of trauma or neurofibromatosis was reported. Based on the presentation and physical examination, a benign nerve sheath tumor was suspected, with schwannoma and neurofibroma as differential diagnoses.

Diagnostic Imaging

The patient underwent magnetic resonance imaging (MRI) of the right ankle, which is the preferred imaging modality for suspected soft tissue tumors, particularly those associated with neural structures. The MRI provided detailed information on the size, location, and characteristics of the mass, essential for differentiating schwannomas from other types of soft tissue tumors.

- MRI Findings:

o On T1-weighted images, the mass appeared isointense to skeletal muscle, which is consistent with typical schwannoma characteristics.

o On T2-weighted images, the lesion exhibited hyperintense signals with a well-defined border, indicative of a slow-growing, encapsulated tumor. The MRI displayed a "target sign," a feature commonly associated with schwannomas, where a hypointense center is surrounded by a hyperintense periphery on T2 images.

o Postcontrast T1-weighted images showed uniform enhancement of the tumor, further supporting the diagnosis of schwannoma.

Additionally, the MRI provided critical information on the mass's relationship with surrounding structures, particularly the lateral sural cutaneous nerve. The findings indicated that the mass was closely related to this nerve without evidence of infiltration, supporting the diagnosis of schwannoma over neurofibroma, as schwannomas are typically encapsulated and do not infiltrate the nerve fascicles.

The MRI findings were corroborated by an ultrasound examination, which showed a hypoechoic, homogeneous mass with well-defined margins. Ultrasonography was beneficial for further confirming the location and encapsulated nature of the mass, although it was less detailed than the MRI in delineating the tumor's relationship with the nerve.

Surgical Approach

Based on the clinical presentation and imaging findings, surgical excision of the mass was recommended to relieve symptoms and prevent potential complications from continued nerve compression. The procedure was performed under spinal anesthesia with the patient positioned prone to provide optimal access to the posterolateral aspect of the ankle.

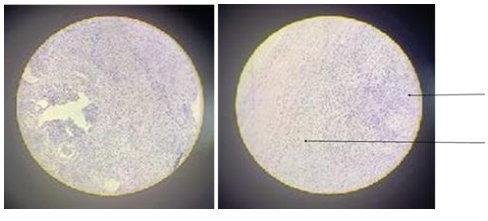

Figure 1(a): Spindle sharped neoplastic cells with many nuclei, without atypia and thick walled hyalinized vessels (100x h&e)

Figure 1(b): Encapsulated tumor with Antoni A and Antoni B areas (100x h&e)

1. Incision and Exposure:

o A longitudinal incision approximately 5 cm in length was made over the swelling on the distal third of the right leg, carefully avoiding major vascular and nerve structures. The skin and subcutaneous tissue were dissected to expose the underlying mass and its relationship with the lateral sural cutaneous nerve.

2. Identification of the Nerve and Tumor:

o The mass was found to be encapsulated, with a clear demarcation from the surrounding tissues. Gentle dissection revealed that the tumor was attached to the lateral sural cutaneous nerve, but due to the encapsulated nature typical of schwannomas, it had not invaded the nerve fascicles.

o Microscopic enucleation was employed to meticulously dissect the tumor from the nerve, ensuring preservation of the nerve fascicles. This technique involved creating a small incision in the epineurium, the outer layer of the nerve, and carefully peeling away the layers to expose the smooth, glistening surface of the schwannoma.

3. Tumor Enucleation:

o Using fine surgical instruments, the schwannoma was enucleated in one piece, separating it from the nerve with minimal disturbance to the surrounding structures. Special attention was given to avoid any damage to the functional nerve fascicles, as intraoperative nerve stimulation was employed to differentiate between functional and nonfunctional fascicles. This technique helped ensure complete removal of the tumor while preserving nerve function.

o The excised tumor measured approximately 3 x 3 cm, corresponding to the MRI findings. No residual tumor tissue was left behind, minimizing the risk of recurrence.

4. Closure and Postoperative Care:

o The incision was closed in layers, ensuring proper approximation of the tissues to promote healing and reduce scar formation. A sterile dressing was applied, and the patient's limb was immobilized temporarily to minimize movement and allow the surgical site to heal.

o Postoperative care included pain management with NSAIDs and monitoring for any signs of infection or neurological deficit. The patient was advised to avoid strenuous activity for the initial recovery period and was scheduled for follow-up visits to assess healing and symptom relief.

Histopathological Examination

The excised tissue was sent for histopathological analysis to confirm the diagnosis. Macroscopically, the tumor appeared well-encapsulated and firm, with a homogenous cut surface. Microscopically, it exhibited the characteristic features of schwannoma:

- Antoni A and B Areas: The tumor displayed alternating regions of Antoni A and Antoni B areas, with Antoni A being densely packed with spindle-shaped Schwann cells arranged in palisades and Antoni B being loosely organized with a myxoid appearance.

- S-100 Protein Staining: Immunohistochemical staining for S-100 protein was positive, confirming the diagnosis as Schwann cells strongly express this protein, making it a reliable marker for schwannomas.

- Vascularity and Cellular Organization: Thick-walled, hyalinized blood vessels were observed within the tumor, a typical feature of schwannomas. There was no evidence of atypia or malignancy, indicating the benign nature of the tumor.

Postoperative Outcome and Follow-Up

The patient's recovery was uneventful, with no neurological deficits or complications observed postoperatively. By the first follow-up visit two weeks after surgery, the patient reported complete relief from pain, and the surgical site had healed well. She was able to resume normal activities gradually, with no signs of recurrence or residual symptoms.

Further follow-up visits at three and six months showed no evidence of recurrence, and the patient remained pain-free. This outcome reinforced the effectiveness of the surgical approach, as complete enucleation of the schwannoma generally results in excellent long-term outcomes with minimal risk of recurrence.

This case highlights the importance of detailed clinical examination, advanced imaging, and careful surgical planning in managing schwannomas, particularly in rare locations like the sural nerve. The combination of MRI and histopathological analysis was essential for accurate diagnosis, while the meticulous enucleation technique ensured nerve preservation and symptom relief. The successful outcome in this patient underscores the role of early identification and appropriate surgical intervention in achieving optimal results for rare peripheral nerve sheath tumors.

IV. Results

Surgical Excision Findings

During the surgical procedure, a well-defined, encapsulated mass was successfully isolated and excised from the lateral sural cutaneous nerve. The tumor measured approximately 3 x 3 cm and exhibited a smooth, glistening surface characteristic of schwannomas. The encapsulation of the mass allowed for meticulous enucleation without disturbing the surrounding nerve fibers. Preservation of nerve integrity was achieved, as confirmed by intraoperative nerve stimulation. The surgical excision was completed without complications, and no residual tumor tissue was observed.

Histopathological Findings

The excised tumor was sent for histopathological analysis, where the findings confirmed the diagnosis of schwannoma. Key microscopic observations included:

1. Antoni A and Antoni B Patterns: The tumor showed classic biphasic histology with Antoni A and Antoni B areas. Antoni A regions were densely packed with spindle cells arranged in palisades (Verocay bodies), while Antoni B areas were loosely organized and myxoid, with fewer cells.

2. Vascularity and Cellular Details: Thick-walled, hyalinized blood vessels were present within the tumor, consistent with benign schwannoma characteristics. No nuclear atypia or mitotic figures were observed, supporting the benign nature of the tumor.

3. Immunohistochemistry: Staining for S-100 protein was strongly positive, confirming the Schwann cell origin of the tumor. This finding was crucial for differentiating schwannoma from other benign or malignant nerve sheath tumors.

The following tables and graphs summarize the key histopathological findings:

Table 1: Histopathological Features of the Schwannoma

Feature	**Observation**
Tumor Size	3 x 3 cm
Capsulation	Well-encapsulated
Antoni A Areas	Present, spindle cell palisades
Antoni B Areas	Present, loosely arranged cells
Vascularity	Thick-walled hyalinized vessels
S-100 Protein Staining	Strongly positive
Atypia	Absent
Mitotic Figures	Absent

Table 1: Histopathological features confirming benign schwannoma.

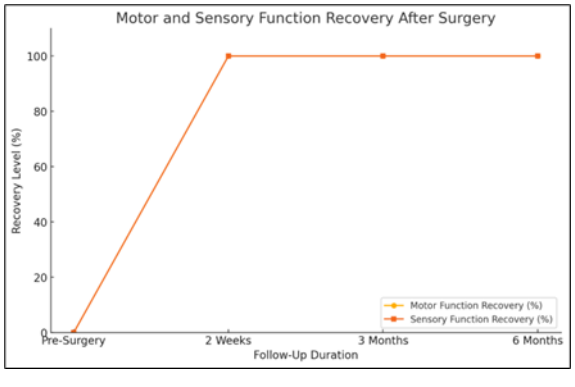

Figure 2. the motor and sensory function recovery levels over the follow-up period

Post-Operative Recovery and Progress

The patient's post-operative recovery was smooth, with no signs of infection or complications. During follow-up assessments at two weeks, three months, and six months, the following observations were noted:

- Pain Relief: The patient reported complete resolution of pain in the affected area.
- Neurological Function: There was no sensory or motor deficit observed in the distribution of the sural nerve.
- Wound Healing: The surgical incision site healed well without any evidence of infection or delayed healing.

Table 2: Post-Operative Progress and Follow-Up Outcomes

Follow-Up Duration	Pain Level	Sensory Deficit	Motor Deficit	Incision Site Healing
2 Weeks	None	None	None	Healed well
3 Months	None	None	None	No complications
6 Months	None	None	None	No signs of recurrence

Table 2: Patient's post-operative progress over the six-month follow-up period.

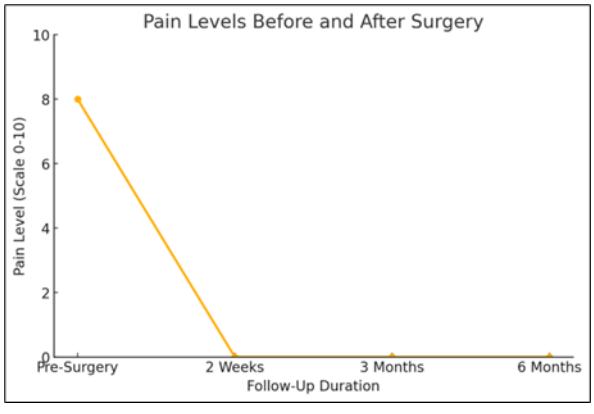

Figure 3. illustrating the patient's pain levels before surgery and at each follow-up

V. Discussion

This case report highlights a rare presentation of schwannoma originating from the lateral sural cutaneous nerve in the lower extremity, a location where peripheral nerve sheath tumors are infrequently encountered. Schwannomas typically arise in nerves of the head, neck, or upper extremities, and their appearance in the lower extremities, particularly in the sural nerve, can complicate diagnosis due to the atypical location and nonspecific symptoms.

The histological features observed in this case—well-demarcated Antoni A and Antoni B areas, hyalinized vessels, and positive S-100 staining—are

characteristic of schwannomas, aligning with findings in existing literature. These features allow for distinction between schwannomas and other nerve sheath tumors, such as neurofibromas, which lack encapsulation and present a more infiltrative growth pattern, often involving the entire nerve. Unlike neurofibromas, schwannomas can be surgically enucleated while preserving nerve function, as demonstrated in this case.

Previous studies have shown that schwannomas are benign, with a low recurrence rate when surgically excised completely. Our case reinforces these findings, as complete tumor removal was achieved without post-operative complications, and no recurrence was observed during follow-up. This outcome is consistent with reported rates of favorable prognosis following complete surgical excision, particularly when encapsulated tumors are involved.

A major challenge in diagnosing schwannomas in atypical locations is their similarity to more common masses, such as lipomas, ganglion cysts, and other benign soft tissue tumors. The use of MRI in this case was pivotal, as it provided critical information on the mass's location, encapsulation, and characteristic "target sign" appearance, which is commonly associated with schwannomas. Imaging findings, combined with clinical examination and histopathology, allowed for an accurate diagnosis. This underscores the importance of a multidisciplinary approach, utilizing clinical, imaging, and histopathological data to avoid misdiagnosis and inappropriate management.

The choice of microscopic enucleation in this case allowed for the preservation of nerve integrity, as demonstrated by the patient's full motor and sensory recovery post-surgery. Intraoperative nerve stimulation further aided in protecting functional fascicles, minimizing the risk of neurological deficits. The patient's rapid and complete recovery from sensory and motor perspectives aligns with outcomes in similar cases where schwannomas were successfully enucleated. Notably, the patient reported immediate and sustained pain relief post-surgery, suggesting that early surgical intervention can effectively manage symptomatic schwannomas without lasting neurological impact.

For clinicians, this case emphasizes the importance of including schwannoma in differential diagnoses for subcutaneous masses in the lower extremities. Schwannomas are rare in this region, but with accurate imaging and histopathology, they can be effectively identified and treated. The early intervention in this case highlights the benefit of prompt surgical excision in avoiding complications like persistent pain and potential nerve damage from prolonged compression.

While the outcomes in this case were favorable, long-term follow-up is recommended for patients with peripheral nerve sheath tumors to monitor for recurrence, which, although rare, can occur. Future studies could further investigate optimal diagnostic markers and imaging features that could aid in differentiating schwannomas from other benign soft tissue masses in atypical locations, potentially refining the diagnostic process.

VI. Conclusion

This case report presents a rare occurrence of schwannoma in the lateral sural cutaneous nerve, highlighting the diagnostic and therapeutic approach necessary for effective management. Schwannomas, though benign and encapsulated, can cause significant discomfort and neurological symptoms when located in atypical areas, such as the lower extremities. This case underscores the importance of including schwannoma in differential diagnoses for subcutaneous masses in the leg and utilizing MRI for accurate localization and characterization. The surgical approach of microscopic enucleation, combined with intraoperative nerve monitoring, enabled complete tumor removal while preserving nerve function, resulting in immediate pain relief and full motor and sensory recovery. Histopathological findings, including Antoni A and B areas and S-100 protein positivity, confirmed the diagnosis, supporting the effectiveness of imaging and histology in identifying schwannomas.In summary, this case illustrates that early diagnosis and precise surgical management can result in favorable outcomes for patients with schwannomas in unusual locations. Clinicians should maintain a high index of suspicion for schwannomas when encountering isolated nerve-associated masses, even in rare sites like the sural nerve, to ensure timely and effective intervention.

REFERENCES

1. Knight, D.M., Birch, R., & Pringle, J. (2007). Benign solitary schwannomas: a review of 234 cases. Journal of Bone and Joint Surgery - British Volume, 89(3), 382–387. doi: 10.1302/0301-620X.89B3.18123.
2. Kim, D.H., Murovic, J.A., Tiel, R.L., Moes, G., & Kline, D.G. (2005). A series of 397 peripheral neural sheath tumors: 30-year experience at Louisiana State University Health Sciences Center. Journal of Neurosurgery, 102(2), 246–255. doi: 10.3171/jns.2005.102.2.0246.
3. Nawabi, D.H., & Sinisi, M. (2007). Schwannoma of the posterior tibial nerve: the problem of delay in diagnosis. Journal of Bone and Joint Surgery - British Volume, 89(6), 814–816. doi: 10.1302/0301-620X.89B6.19077.
4. Sidani, C., Saraf-Lavi, E., Lyapichev, K.A., Nadji, M., & Levi, A.D. (2015). Acute presentation of brachial plexus

schwannoma secondary to infarction. Neuroradiology Journal, 28(3), 333–336.

5. Beaman, F.D., Kransdorf, M.J., & Menke, D.M. (2004). Schwannoma: radiologic-pathologic correlation. Radiographics, 24(5), 1477–1481. doi: 10.1148/rg.245045001.

6. Siqueira, M.G., Socolovsky, M., Martins, R.S., Robla-Costales, J., Di Masi, G., Heise, C.O., & Cosamalón, J.G. (2013). Surgical treatment of typical peripheral schwannomas: the risk of new postoperative deficits. Acta Neurochirurgica, 155(9), 1745–1749. doi: 10.1007/s00701-013-1818-6.

7. Murphey, M.D., Smith, W.S., Smith, S.E., Kransdorf, M.J., & Temple, H.T. (1999). Imaging of musculoskeletal neurogenic tumors: radiologic-pathologic correlation. Radiographics, 19(5), 1253–1280. doi: 10.1148/radiographics.19.5.g99se101253.

8. Ahmed, A.R., Watanabe, H., Aoki, J., Shinozaki, T., & Takagishi, K. (2001). Schwannoma of the extremities: the role of PET in preoperative planning. European Journal of Nuclear Medicine, 28(10), 1541–1551. doi: 10.1007/s002590100584.

9. Koga, H., Matsumoto, S., Manabe, J., Tanizawa, T., & Kawaguchi, N. (2007). Definition of the target sign and its use for the diagnosis of schwannomas. Clinical Orthopaedics and Related Research, 464, 224–229. doi: 10.1097/BLO.0b013e3181583422.

10. Weiss, S.W., Langloss, J.M., & Enzinger, F.M. (1983). Value of S-100 protein in the diagnosis of soft tissue tumors with particular reference to benign and malignant schwann cell tumors. Laboratory Investigation, 49(3), 299–308.