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MRI Findings and Diagnostic Significance of Soft Tissue Schwannomas in the Extremities

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Abstract: *Objective:* To analyze the MRI features and rare manifestations of schwannomas of the extremities to improve diagnosis. *Methods:* Retrospective analysis of 23 cases of schwannomas in the extremities confirmed by surgical pathology, summarizing its signs, signal characteristics and MRI enhancement. *Results:* Among the 23 cases, 20 were single lesions, and 3 were multiple lesions, resulting in a total of 28 lesions. The distribution of these lesions included 7 in the thigh, 9 in the calves, 4 in the armpits, 3 in the hips, and 4 each in the upper arms and forearms. Additionally, there was one lesion located in the groin. On T1-weighted imaging (T1WI), the lesions showed iso-intensity or hypo-intensity. On T2-weighted imaging (T2WI), they appeared slightly hyperintense or hyper-intense. Some lesions exhibited multiple small vesicle-like higher signals, cystic changes, and fiber spacing on T2WI. Furthermore, one lesion showed a liquid-liquid plane. The "target sign" was observed in 18 lesions (64.3%) and "neuropathic signs" were present in six lesions (21.4%). Finally, it was noted that on MRI enhancement, the lesions demonstrated uniform or uneven enhancement. The lesions were uniformly or unevenly enhanced on MRI enhancement. *Conclusions:* The MRI findings of schwannoma in the extremities exhibit specific characteristics. The cystic changes on T2WI also display distinct features. Recognition of rare MRI findings, such as cystic changes, liquid-liquid plane and septum, should be emphasized to enhance the accuracy of pre-diagnosing schwannomas.

Keywords: Schwannomas; Extremities; Magnetic resonance imaging

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1. Introduction

Schwannoma is a benign tumor originating from Schwann cells of the nerve sheath. It is non-invasive and the most common tumorous lesion in peripheral nerves of the extremities [1]. However, the accurate preoperative diagnosis of schwannomas in the extremities is a topic of controversy and often results in misdiagnosis or delayed diagnosis [2,3]. Patients can benefit from an accurate preoperative diagnosis [4]. The aim of this study was to analyze the general features, intralesional signal characteristics and rare atypical manifestations of this disease on MRI. Additionally, the study aimed to explore the potential causes of the disease and its diagnostic significance in order to enhance understanding and improve the diagnostic accuracy of the disease.

2. Materials and methods

2.1. Clinical data

From August 2014 to January 2024, a total of 23 cases of soft tissue schwannoma of the limbs were diagnosed by MRI and subsequently confirmed through surgical operation and pathology examination. The cases included 13 males and 10 females. The ages of the participants ranged from 23 to 74 years old, with an average age of 51 years old. Most of the clinical symptoms presented as local masses, with no or mild tenderness and occasional numbness in the limbs or hypoaesthesia of the skin.

2.2. MRI scan technique

MRI examinations were conducted using Philips 1.5T and 3.0T MR scanners equipped with either a body coil or a knee coil. Conventional transaxial, coronal and sagittal scans were performed using the following scan sequences: (1) TSE T1WI (TR 500–1177 ms, TE 17–20 ms), T2WI (TR 3567–7169 ms, TE 100–130 ms), PDWI (TR 1512–3583 ms, TE 7–30 ms), and (TSE) T2WI SPAIR with fat suppression (TR 2354–7239, TE 45–70). The slice thickness was set at 3–8 mm with a slice spacing of 3–6 mm. Gd-DTPA, at a dosage of 0.2 mmol/kg, was utilized as the contrast agent in conjunction with T1-weighted imaging (TR 621–660 ms, TE 20–25 ms) for lipid suppression sequence or T2-weighted imaging using SPAIR (TR 2354, TE 60).

2.3. Image analysis

All image evaluation contents include the location, number, shape, boundary, signal characteristics, and special signs (such as target sign and nerve) of the lesion. The signal features and signs were compared with the surgical findings and pathological diagnosis.

3. Results

3.1. Lesion location and general characteristics

In a cohort of 23 patients, a total of 28 lesions were identified. These lesions were distributed as follows: 7 in the thigh, 9 in the calf, 4 in the popliteal fossa, 3 in the buttock, 4 in the upper arm and forearm, and 1 in the groin. The lesions were located within subcutaneous, intermuscular or intramuscular spaces. Three routine enhanced examinations were conducted within this cohort.

3.2. MRI Performance

A 37-year-old male patient presented with a complaint of a mass in the right knee accompanied by intermittent pain. Upon examination, two lesions were observed in the soft tissue of the distal femur and the proximal humerus. The lesions exhibited hypointensity on T1-weighted imaging (T1WI) (**Figure 1**). Additionally, neurogenic entry and exit signs were evident beneath the lesion located at the distal end of the femur. Furthermore, the lesions appeared hyperintense on T2-weighted imaging (T2WI) with a contour signal and the lesions appeared slightly hyperintense or hyperintense (**Figure 2**). There were 6 (21.4%) small cystic changes and stratification around the center or periphery of the lesion (**Figure 2**).

Figure 1. Iso-hypointense or hypointense compared to muscle on T1WI.

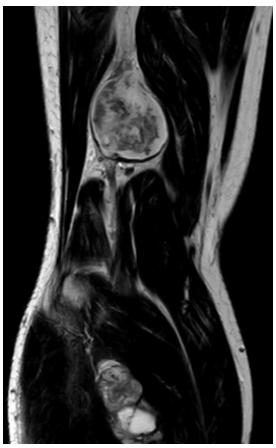

Figure 2. Lesions appeared slightly hyperintense or hyperintense on T2WI with 6 small cystic changes.

A 64-year-old female patient has been experiencing left calf skin pain for the past 7 months. Upon examination, a soft tissue mass was observed on the medial left femur, exhibiting a slightly hyperintense or hyperintense signal on PDWI. Additionally, a stratified and cord-like low signal was identified within the lesion (**Figure 3**). For **Figure 4**, a 71-year-old woman experienced right knee and calf pain for a duration of 1 month. Additionally, she reported feeling weakness in the skin on the outside of her right calf, as well as on the back and sole of her foot. A high signal was observed on the T2WI (SPAIR) of the axillary muscle space. The lesions exhibited a low signal and patchy, small, round, higher signal.

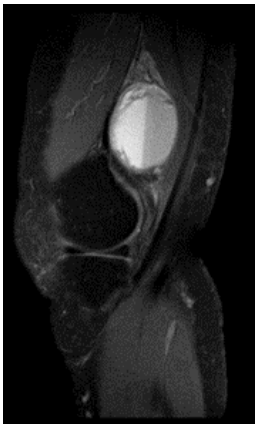

Figure 3. Fluid level observed with 6 cases of lesion in one case.

Figure 4. 6 cases (21.4%) intervals within the lesions.

In **Figure 5**, A 27-year-old woman presented with a non-tender mass on the outer thigh that had been present for 2 years. Magnetic resonance imaging of the right femur revealed a cluster-like, isometric, mixed signal in the lateral femoral muscle, resembling a “swampy ground” in high and low phases on T2-weighted images. The three lesions on T2WI exhibited patchy mixed signals with alternating high and low levels, resembling the change of marshland. This appearance was temporarily referred to as “swampland-like” (**Figure 5**). For the case in **Figure 6**, a 66-year-old woman presented with a painless mass in her right thigh that had been present for 2 years. MRI enhancement revealed significant uneven enhancement, with no strengthening of the inner cystic zone [5]. The lesion appeared hyperintense on lipography. Upon enhancement, it exhibited clear and consistent or varied enhancement, with the cystic area showing no enhancement (**Figure 6**).

A 28-year-old man presented with a complaint of a calf mass persisting for 1 year in **Figure 7**, without any associated swelling or tenderness. The lesion was located between the inner and outer heads of the gastrocnemius muscle, demonstrating hyperintensity on T2-weighted imaging. Additionally, the target and

neurogenic entry and exit could be visualized. The signs were analyzed as the "target sign" (**Figure 2** and **Figure 7**) was present in 18 lesions in this group (64.3%), while the "nerve entry sign" (**Figure 2** and **Figure 7**) was observed in 6 lesions in this group (21.4%). The "fat separation (wrapping) sign" was present in all 4 lesions in this group (14.2%), and the "fat tail sign" was seen in 4 lesions within this group (14.2%). Additionally, there were 8 lesions (28.6%) that exhibited two or more signs simultaneously.

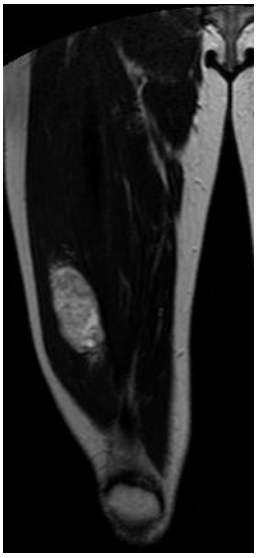

Figure 5. "Swampland-like" appearance of three lesions on T2WI.

Figure 6. Clear and consistent enhancement with cystic area shows none enhancement.

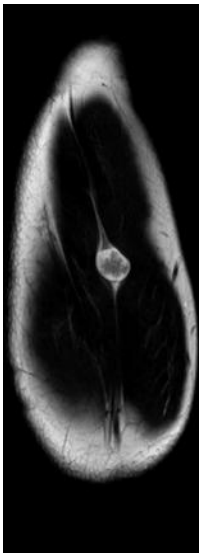

Figure 7. "Target sign" of nerve root imaging.

4. Discussion

The most common sites of peripheral schwannoma are the extremities, with the majority occurring on the flexion side and typically affecting individuals aged 20–60 years old. There is no difference in the incidence between males and females [1]. In this study, the four limbs are defined as follows: the upper limbs are defined by the shoulders, while the lower limbs are defined by the groin, and the buttocks are also included in this classification. Most of the tumors were spindle-shaped and oval soft tissue masses located in the nerve running area, exhibiting clear boundaries and single lesions. The lower limb lesions accounted for 85% of this group, while various studies have indicated that the proportion of schwannomas in the upper and lower limbs differs, with approximately 55% and 58%, respectively [1,5]. The higher proportion of lower limb involvement in this group may be attributed to differences in selection. Additionally, approximately 13% of the cases presented with multiple lesions in the lower extremities. While some studies have suggested a potential association between schwannoma and neurofibromatosis type 2 [3], no such link was found in the diagnosis of these cases. Microscopically, the tumor is characterized by both Antoni A and Antoni B areas, with variable distribution and proportion. Furthermore, secondary degenerative changes, including cystic change, hyalinization, ulceration and mucoid change, can also be observed [6]. Malignant transformation of schwannomas is rare, accounting for approximately 5–10% of all soft tissue sarcomas [7].

MRI is superior in displaying soft tissue lesions. Due to the potential for schwannoma to exhibit a range of secondary degenerative changes, MRI signals can be variable and irregular. This is particularly evident when there is bleeding, necrosis or cystic change present, resulting in a more mixed signal pattern. Therefore, the analysis of specific signs and rare manifestations holds significant value in aiding diagnosis [8–10]. The target

sign, characterized by a slightly low signal in the center and a high signal in the periphery on T2WI [10], was associated with a display rate of 64.3%. Pathologically, this pattern is based on the distribution of Antoni A (located in the central area) and Antoni B area (located in the peripheral "target edge" area). The neuro-entering sign is characterized by a fusiform mass along the nerve trunk, closely related to the nerves. Nerve ingression at both sides of the tumor is commonly observed in deep, large nerves, with occasional occurrences of subcutaneous schwannoma. The display rate of this group was 21.4%. Additionally, the fat separation (wrapping) sign indicates the presence of fat surrounding the tumor, which is clearly displayed on T1WI. The fat separation (wrapping) sign is characterized by the presence of fat surrounding the tumor, which is clearly depicted on T1-weighted imaging (T1WI). This sign often indicates slow tumor growth, with the fat being displaced and a thin layer of fat being preserved. Fat tail refers to the intermuscular fat shadow located at a tumor's upper or lower pole. While the fat split sign may have some diagnostic value for intramuscular schwannoma [8], it is important to note that fat separation and fat tail signs can also be present in other diseases and therefore will not be further discussed here. In addition, there were three cases of "marshland-like" appearance on T2WI. This was attributed to the uneven distribution of Antoni A and Antoni B as well as inherent cystic changes. The presence of a fluid level was rare, occurring only when cystic changes were combined with bleeding. On T2WI, the probability of low signal separation was approximately 70%, with an interval rate of about 21.4% in this group [9]. Further imaging-pathological comparative studies are needed to demonstrate the value and significance of interval in diagnosis and differential diagnosis. The degree of enhancement varied according to the distribution of tumor tissues, resulting in homogeneous or uneven enhancement in the center of the mass, unenhanced cystic areas and necrosis within solid masses, or no obvious enhancement.

It is important to distinguish schwannomas from the following diseases:

(1) Neurofibroma may also present with features, such as targeting, nerve penetration and fat wrapping. However, most solitary neurofibromas occur in individuals aged 20–30 years old, slightly younger than schwannomas. They typically originate from dermal or subdermal cutaneous nerves [11].

(2) Intramuscular myxoma commonly affects the thigh and upper arm muscle group. Linear separation may be observed within the lesion, and there is no true capsule with a tendency for infiltration. Edema and linear fat signal can be seen around the lesion, with diagnostic significance attributed to the linear fat signal [12]. Additionally, this condition is found adjacent to the mass without the involvement of accompanying nerves.

(3) Myxoid liposarcoma can be identified by a small amount of fat signal within the lesion.

5. Conclusions

The diagnosis of schwannoma of the extremities is generally straightforward when typical MRI findings are present. However, it should be considered as a provisional diagnosis and included in the differential diagnosis when there are indications of cystic changes, uneven signal, and fluid levels on MRI. Analysis of MRI expression characteristics and enhancement can help improve the accuracy of pre-diagnosis of schwannoma.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Zhou H, Yao C, Dong Y, et al., 2022, Clinical Characteristics and Management Experience of Schwannoma in Extremities: Lessons Learned from a 10-Year Retrospective Study. Frontier of Neurology, 13: 1083896.

[2] Suzuki A, Kanda T, Yoshimizu T, et al., 2021, Investigation of Schwannomas in the Forearms, Hands, and Digits: A Retrospective Study. The Journal of Hand Surgery (Asian-Pacific Volume), 26(1): 17–23.

[3] Pertea M, Filip A, Huzum B, et al., 2022, Schwannoma of the Upper Limb: Retrospective Study of a Rare Tumor with Uncommon Locations. Diagnostics (Baseline), 12(6): 1319.

[4] Istefan E, Belstock J, Dahlin LB, et al., 2023, Surgery of Schwannoma in the Upper Limb-Sensitivity and Specificity of Preoperative Magnetic Resonance Imaging and Relation Between Tumour Size and Symptoms. BMC Musculoskeletal Disorders, 24(1): 713.

[5] El Sayed L, Masmejean E, Lavollé A, et al., 2022, Clinical Results After Surgical Resection of Benign Solitary Schwannomas: A Review of 150 Cases. Orthopaedics & Traumatology: Surgery & Research, 108(4): 103281.

[6] Majumder A, Ahuja A, Chauhan DS, et al., 2021, A Clinicopathological Study of Peripheral Schwannomas. Medicine and Pharmacy Reports94(2): 191–196.

[7] Albert P, Patel J, Badawy K, et al., 2017, Peripheral Nerve Schwannoma: A Review of Varying Clinical Presentations and Imaging Findings. The Journal of Foot and Ankle Surgery, 56(3): 632–637.

[8] Salunke AA, Chen Y, Tan JH, et al., 2015, Intramuscular Schwannoma: Clinical and Magnetic Resonance Imaging Features. Singapore Medical Journal, 56(10): 555–557.

[9] Chang WC, Huang GS, Lee HS, et al., 2009, Fluid-Fluid Level in Peripheral Nerve Schwannoma: Report of a Case with Histological Correlation. Clinical Imaging, 33(3): 248–251.

[10] Ishizawa M, Okabe H, Matsumoto K, et al., 2021, Histopathological Explanation of the MRI Target Sign in Extra-Axial Schwannomas. Journal of Orthopaedic Science, 26(4): 660–665.

[11] Stull MA, Moser RP Jr, Kransdorf MJ, et al., 1991, Magnetic Resonance Appearance of Peripheral Nerve Sheath Tumors. Skeletal Radiology, 20(1): 9–14.

[12] Petscavage-Thomas JM, Walker EA, Logie CI, et al., 2014, Soft-Tissue Myxomatous Lesions: Review of Salient Imaging Features with Pathologic Comparison. Radiographics, 34(4): 964–980.