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Lymphoscintigraphy and Sentinel Lymph Node Identification in Cutaneous Melanoma: Diagnostic Value and Clinical Implications

S.E. Abaid[1*], H. Alaoui[1], A. Salami[1], S. Abidar[1], M. Ait Idir[1], M. A. Bsiss[1], A. Matrane[1]

[1]Nuclear Medicine Department, Hematology Oncology Centre, Mohammed VI University Hospital, Marrakesh, Morocco

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***Corresponding author:** S.E. Abaid
Nuclear Medicine Department, Hematology Oncology Centre, Mohammed VI University Hospital, Marrakesh, Morocco

Abstract **Case Report**

Cutaneous melanoma is a malignant tumor with a high metastatic potential, whose staging largely depends on regional lymph node status. Lymphoscintigraphy, combined with sentinel lymph node biopsy, constitutes an essential step in the staging workup, allowing precise identification of metastases while limiting the morbidity associated with systematic lymph node dissections. The reported case describes a 54-year-old female patient with a plantar acral lentiginous melanoma. Lymphoscintigraphy, performed after injection of technetium-99m colloids, revealed a hyperactive right inguinal sentinel lymph node, with secondary lymphatic relays. Intraoperatively, combined localization using a handheld gamma detector and a portable GammaSUP-II gamma camera enabled targeted excision of the node, whose histopathological analysis confirmed the presence of micrometastases. The primary lesion, meanwhile, was an in situ melanoma. Postoperative course was marked by a cutaneous tissue loss requiring reconstructive follow-up, without major infection. This case illustrates the crucial utility of lymphoscintigraphy and intraoperative localization for personalized staging, particularly in locations such as the acral region where lymphatic drainage can be complex.

Keywords: Melanoma, Sentinel lymph node, Lymphoscintigraphy, Lymphatic mapping.

INTRODUCTION

Cutaneous melanoma is a malignant neoplasm arising from melanocytes and nevus cells, developing primarily on the skin and, more rarely, in other locations. It is a potentially lethal cancer characterized by a high risk of metastasis. The global incidence of melanoma has increased rapidly over the past 50 years and varies according to age, phototype, and geographic altitude: it is higher in fair-skinned individuals, in low-altitude regions, and among the elderly, while remaining one of the most common cancers in adolescents and young adults [1].

The prognosis of melanoma strongly depends on regional lymph node status, which is one of the most important prognostic factors. In this context, the sentinel lymph node (SLN) is defined as the first lymphatic relay draining the primary tumor and plays a central role in disease staging. Sentinel lymph node biopsy enables early detection of nodal micrometastases while reducing the morbidity associated with systematic lymph node dissection. This procedure is now considered a standard step in melanoma staging, allowing precise evaluation of lymphatic involvement and tailored surgical planning [2].

Lymphoscintigraphy, through perilesional injection of technetium-99m-labeled colloid, allows preoperative mapping of lymphatic pathways and identification of sentinel lymph nodes. Earlier studies have shown that it can identify multiple nodes in patients and reveal unexpected drainage sites, particularly for melanomas located on the trunk [3].

However, planar imaging alone may be limited by low anatomical resolution and sometimes ambiguous node localization. Integration with SPECT/CT provides significant added value, combining the functional information of scintigraphy with detailed anatomical imaging. This allows the identification of additional nodes and improves surgical planning. Specifically, in head and neck melanomas, the use of SPECT/CT has not only increased precise node localization but has also been associated with a higher likelihood of detecting a positive SLN [4–6].

Thus, lymphoscintigraphy is now a central tool in nodal staging for patients with melanoma, enhancing

staging accuracy, guiding surgery, and contributing to optimized patient management. The present article aims to examine in detail the role of this technique, evaluate its diagnostic performance, and discuss its limitations and futures perspectives.

CASE REPORT

A 54-year-old female patient presented with a nodular lesion located on the plantar surface of the right foot, evolving over approximately one year, characterized by progressive enlargement and a changé in color of a preexisting nevus. She also reported abdominal pruritus and the appearance of hyperpigmented macules in the same area. The evolution occurred in an afebrile context with preserved general condition. Her medical history included depression under treatment.

Detailed dermatological examination revealed hairless skin in the affected area, with an asymmetric, dyschromic nodular lesion, black and brown in places, with irregular borders, a crusted surface, non-pruritic, measuring 1.5 cm × 1 cm, fixed to the underlying tissue, and tender on palpation. There was also a large, poorly demarcated hyperpigmented area on the left abdominal flank, along with several nevi scattered across the skin surface. The remainder of the physical examination was unremarkable (Figures 1 and 2).

An ultrasound of the inguinal lymph node regions revealed infracentimetric and juxtacentimetric inguinal nodes with preserved fatty hilum, as well as ipsilateral infracentimetric inguinal adenopathies.

Excisional biopsy of the lesion, performed in three fragments, revealed features consistent with plantar acral lentiginous melanoma in situ, confirming the histopathological diagnosis and allowing correlation with preoperative lymphatic mapping. A plastic surgery consultation was requested to plan complete lesion excision and organize surgical management.

For diagnostic evaluation to localize sentinel lymph nodes, lymphoscintigraphy was performed after four perilesional subcutaneous injections of 0.8 mCi of 99mTc-labeled nanocolloids. Imaging was acquired at 1 hour and 1 hour 30 minutes post-injection, with static planar images obtained in anterior, right lateral, and right anterior oblique views. The study revealed, in the right inguinal fold, an intense and voluminous hyperactive focus corresponding to the first lymph node draining the plantar tumor, considered the sentinel lymph node, along with additional smaller foci located more proximally (Figure 3).

Following lymphatic mapping, the sentinel lymph node identified in the right inguinal fold was intraoperatively localized using a portable GammaSUP-II gamma camera, in combination with a handheld gamma probe, allowing precise, real-time localization of the target node (Figure 4 and 5). Surgical excision of the sentinel node was performed, along with complete excision of the plantar lesion according to plastic surgery recommendations, preserving surrounding structures (Figure 6). The specimens were sent for histopathological analysis, confirming the presence of lymph node micrometastasis.

Postoperative course was marked by tissue loss at the tumor excision site, requiring reconstructive surgery follow-up and appropriate local care (Figure 7). No major infectious complications were reported, and the patient maintained satisfactory plantar function, although clinical follow-up remains necessary to assess healing and reconstruction quality.

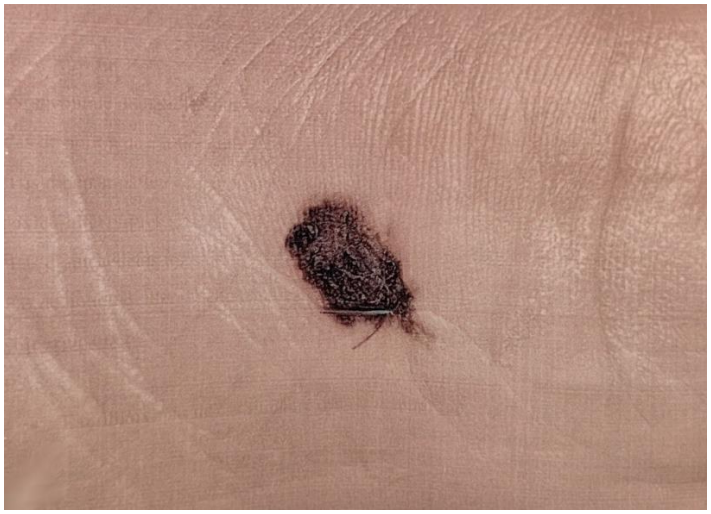

Figure 1: Dermoscopic appearance of the plantar lesion

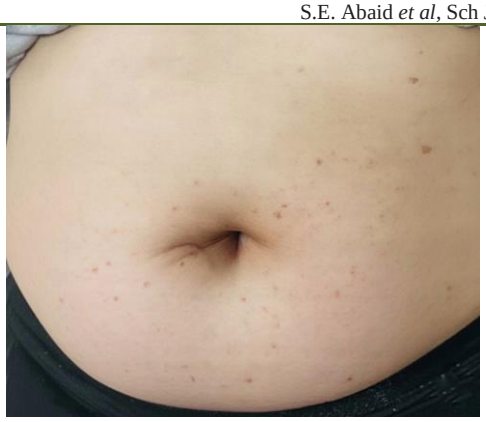

Figure 2: Abdominal hyperpigmentation with scattered nevi

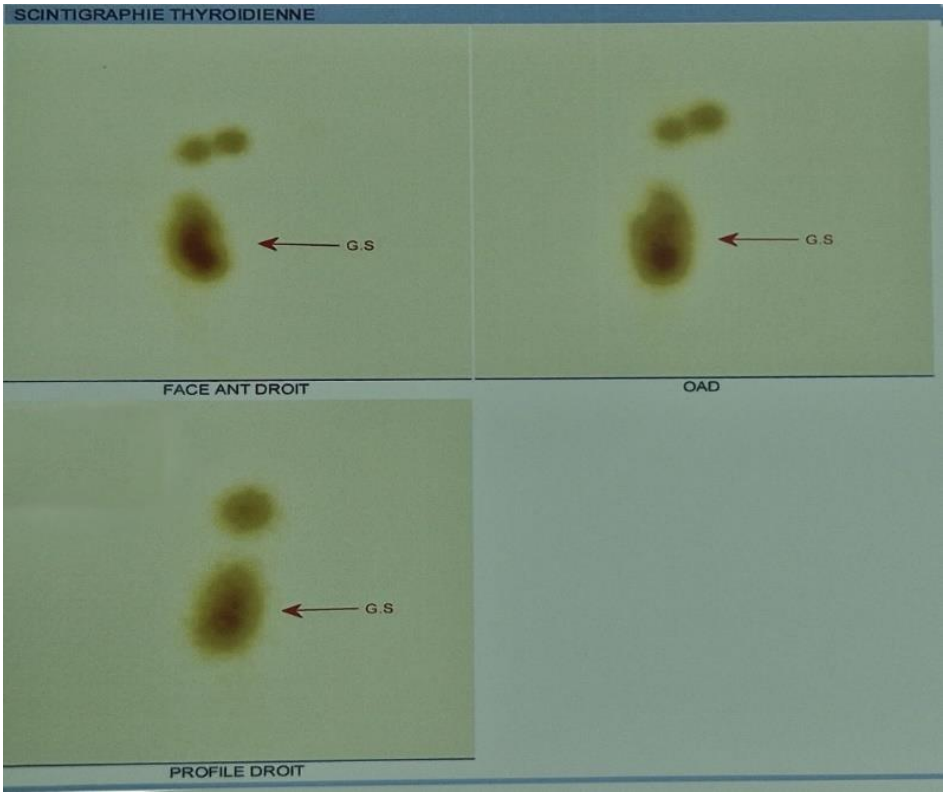

Figure 3: Lymphoscintigraphy in three static projections

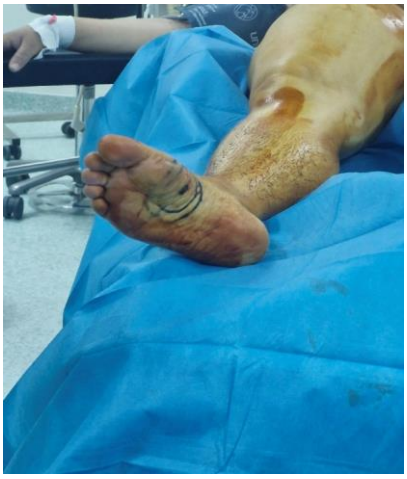

Figure 4: Surgical site with plantar melanoma and perilesional markings before excision

Figure 5: Portable gamma probe system for intraoperative detection of the sentinel lymph node with intense activity

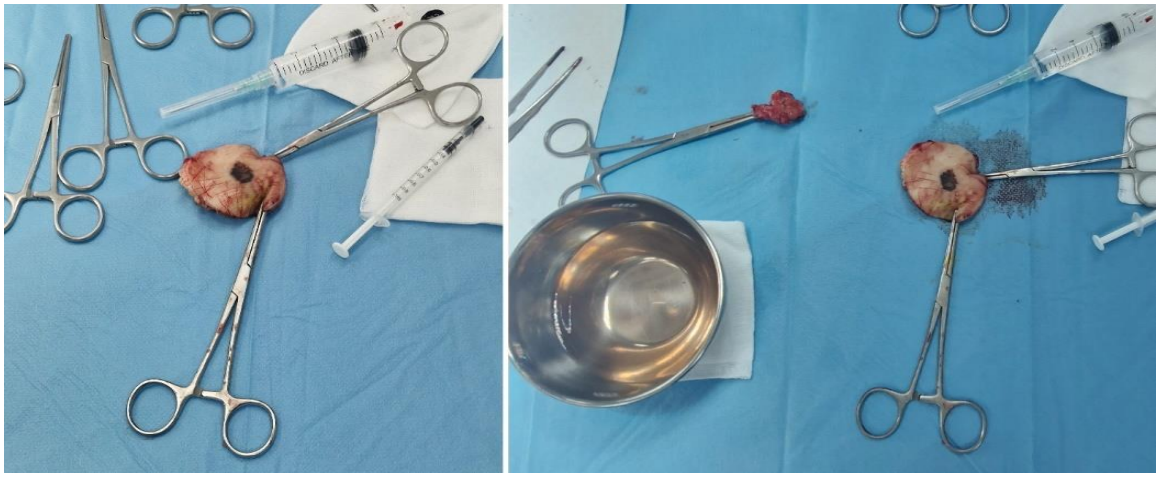

Figure 6: Excision specimens: plantar melanoma and sentinel lymph node

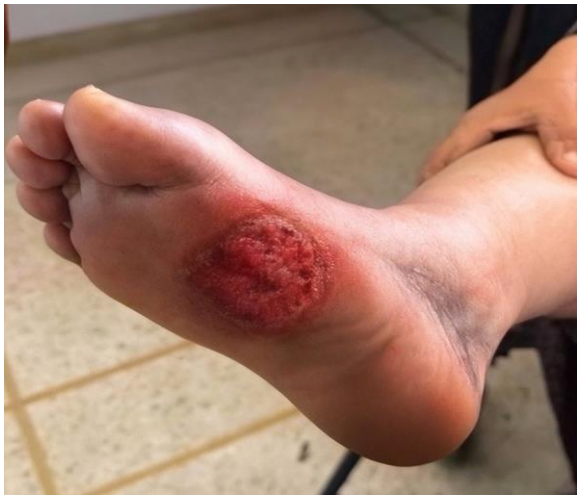

Figure 7: Post-excisional cutaneous tissue loss during postoperative follow-up

DISCUSSION

Primary cutaneous melanoma exhibits a strong propensity for regional lymphatic dissemination, with draining lymph nodes representing the first frequent sites of metastasis. In patients without clinically or radiologically evident lymphadenopathy, the likelihood of macroscopic nodal involvement remains low, limiting the diagnostic value of imaging modalities such as PET/CT. In this context, sentinel lymph node biopsy (SLNB) remains the reference method for staging, allowing early detection of micrometastases while reducing morbidity associated with complete lymph

node dissection [7,8]. The prognostic value of SLNB is well established, with the presence of a metastatic sentinel node being a major predictor of recurrence and melanoma-specific survival.

This prognostic role is particularly notable in acral lentiginous melanoma (ALM), a subtype characterized by more aggressive biology and often atypical lymphatic drainage patterns. An analysis from the National Cancer Database showed that ALM was associated with nearly double the risk of sentinel node positivity, with positive SLN rates reaching 18.39% at stage IB and 39.53% at stage II according to AJCC-8 classification [9]. In patients with thin melanomas (<1 mm), SLNB indication should be individualized, considering histopathological and demographic factors associated with increased nodal metastasis risk, including ulceration, thickness >0.75 mm, Clark level IV, high mitotic rate, younger age, or male sex [10]. Integration of these factors into clinical decision-making optimizes patient selection and avoids unnecessary interventions.

Lymphoscintigraphy, performed via perilesional injection of 99mTc-labeled colloid, is the reference technique to map lymphatic pathways and localize the sentinel node preoperatively. However, planar imaging alone has limitations, including relatively low anatomical resolution and sometimes ambiguous node localization, especially in areas with complex drainage such as the trunk, head and neck, or extremities [4]. The integration of SPECT/CT represents a major advance, combining functional scintigraphic mapping with detailed anatomical CT imaging. This allows not only the identification of additional nodes undetected by planar imaging but also improves surgical planning and excision accuracy. In a study of 85 patients, SPECT/CT detected 12 additional sentinel nodes and altered the surgical plan in 35% of patients [4]. These results were confirmed by a meta-analysis of 17 studies including 1,438 patients, demonstrating a sentinel node detection rate of 98.28% with SPECT/CT versus 95.53% with planar imaging, influencing surgical strategy in approximately 37% of cases [5].

Tracer injection technique is crucial to ensure homogeneous distribution and accurate lymphatic mapping. Typically, the dose is divided into four peritumoral intradermal injections, in accordance with EMA recommendations for 99mTc-nanocolloid [11]. After injection, static acquisitions are performed between 30 and 60 minutes, visualizing the nodes for 5–10 minutes depending on the anatomical region. This method is supported by the radioguided results of Mariani et al., which show that optimal mapping requires intradermal or subcutaneous injections around the tumor [12]. To facilitate surgical localization, identified sentinel nodes are projected onto the skin by the nuclear physician, ensuring marking in a position identical to that planned for surgery. This anatomical correspondence between scintigraphy and surgery is recommended in EANM guidelines to ensure the visualized site accurately matches the operative field [13]. During surgery, a portable gamma probe allows real-time detection of gamma emissions from the labeled nodes, guiding intraoperative excision efficiently and safely [14].

Clinically, these data underscore the importance of precise nodal mapping to optimize sentinel node identification, particularly in acral melanomas and locations with unpredictable drainage. Intraoperative localization combining a handheld gamma probe and portable gamma camera enables real-time detection of the target node, reducing the risk of incomplete excision or false negatives [15]. Combining SLNB with high-quality preoperative imaging thus contributes to reliable staging, essential for therapeutic decision-making, surgical planning, and tailored follow-up.

Although SLNB is less invasive than complete lymph node dissection, it is not without risk. Complications such as seromas, infections, hematomas, or lymphedema have been reported, with an overall incidence of approximately 11–12% [16]. These generally moderate complications require careful postoperative monitoring, particularly in sensitive anatomical areas or after excision of plantar or acral lesions. Management of sequelae, including tissue loss or scar-related issues, is an essential part of surveillance and functional rehabilitation.

Long-term postoperative follow-up is crucial after SLNB and primary excision, as late recurrences can occur. In a cohort of 515 patients with negative SLNs, 16% experienced recurrence after a median follow-up of 61 months, indicating a false-negative rate of approximately 4% [17]. A prospective ten-year study shows that although SLN positivity is associated with lower 5-year survival, it is not an independent predictor of recurrence or mortality after five years, with melanoma characteristics playing a major role [18]. Moreover, SLNB-related sequelae such as lymphedema may appear several years after the procedure, with a reported incidence of 9.7% over a mean follow-up of more than 4 years [19]. Finally, the interval between lymphoscintigraphy and SLNB has not been shown to negatively impact long-term survival; a study of 925 patients demonstrated that performing the biopsy the day after scintigraphy did not alter overall or melanoma-specific survival beyond six years [20]. Long-term follow-up should therefore combine dermatological exams, lymph node palpation, reconstructive monitoring if necessary, and surveillance of functional sequelae to optimize prognosis and quality of life.

In conclusion, the literature and current practices demonstrate that the combination of precise preoperative mapping, appropriate intraoperative localization, and targeted SLNB constitutes the standard for melanoma staging, particularly for high-risk subtypes

such as ALM. This strategy optimizes diagnosis, guides surgical management, allows more accurate prognostic evaluation, and helps reduce morbidity associated with extensive nodal procedures [21].

CONCLUSION

Sentinel lymph node biopsy (SLNB), guided by lymphoscintigraphy, is now a cornerstone in the staging of cutaneous melanoma, allowing early detection of micrometastases and optimized surgical management. Precise preoperative mapping, combined with intraoperative localization using a gamma probe and portable gamma camera, significantly improves sentinel node identification, reduces the risk of false negatives, and guides therapeutic strategy. Acral melanomas, as illustrated by the presented case, require particular attention due to their sometimes unpredictable lymphatic drainage and aggressive potential. The integration of advanced imaging techniques, such as SPECT/CT when available, provides an additional advantage for surgical planning and accurate staging. Finally, despite the limited morbidity compared with complete lymph node dissection, postoperative monitoring—particularly of cutaneous tissue loss—remains essential to ensure adequate functional and aesthetic follow-up. These findings confirm the central role of lymphoscintigraphy and SLNB in modern melanoma management, contributing to improved prognosis and patient quality of life.

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Declaration

Conflict of interest: All the authors (Saad Eddine Abaid, Hamza Alaoui, Abdelkafi Salami, Said Abidar, Malika Ait Idir, Mohammed Aziz Bsiss, Aboubaker Matrane) declare that there is no confict of interest that could be perceived as prejudicing the impartiality of the research reported.

Informed consent: Written informed consent was obtained prospectively from the patients for the use of their clinical data.

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