










REVIEW ARTICLE

Desmoplastic melanoma: a review of its pathology and clinical behaviour, and of management recommendations in published guidelines

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Abstract

Desmoplastic melanomas are uncommon. Their behaviour differs from that of other melanoma subtypes; therefore, management guidelines for non-desmoplastic melanomas may not be applicable. This review sought to examine all available evidence relating to the behaviour and management of desmoplastic melanomas, based on review of all relevant English-language publications, and to critically assess the recommendations for their management in current published melanoma management guidelines. Compared with other melanoma subtypes, patients with 'pure' desmoplastic melanomas (where $\geq 90\%$ of the invasive melanoma is of desmoplastic melanoma subtype) have much lower rates of sentinel node positivity and distant metastasis. Local recurrence rates are higher for desmoplastic melanomas, but resection margins wider than those recommended for non-desmoplastic melanomas have not been shown to be of benefit. Adjuvant radiotherapy reduces the risk of local recurrence when a satisfactory histological clearance (≥ 8 mm) cannot be achieved. Of 29 published melanoma management guidelines identified, only 11 specified management for desmoplastic melanomas, while seven simply stated that the feature should be reported. Desmoplastic melanoma is a unique melanoma subtype with biology that differs from that of other melanoma subtypes. It requires specific management strategies but few current guidelines address these.

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Desmoplastic melanoma (DM) is an uncommon melanoma subtype, comprising only 1–4% of all primary cutaneous melanomas. DM may be difficult to recognize, both clinically and

pathologically, and its behaviour differs from that of non-desmoplastic melanoma (non-DM).^{1–5} In this article, the special features of DM and the results of reported management

strategies are reviewed. In addition, the evidence supporting the current recommendations in published melanoma management guidelines that specifically mention the management of DM is critically assessed.

Identification of all English-language publications related to desmoplastic and neurotropic melanomas and guideline recommendations for their management was achieved by searching Medline, Embase and Cochrane Library databases using the terms melanoma, desmoplastic, neurotropic. From the assembled collection of 254 unique articles, 36 articles containing clinically relevant material and 29 published melanoma management guidelines were then examined in detail.

Clinical and pathological characteristics of desmoplastic melanomas

Desmoplastic melanoma is characterized histologically by variably pleomorphic, spindle-shaped cells separated by collagen fibres, with a fibrotic stromal reaction termed desmoplasia (Fig. 1).⁶ In contrast, the spindle cells in non-desmoplastic spindle cell melanomas are in direct contact with one another. The cells resemble fibroblasts, as found in scar tissue, but usually display a degree of cytological atypia.² The amount of collagen present is highly variable. In many DMs, there is also a non-DM component. Immunohistochemically, DM differs from non-DM in its expression of melanoma-associated antigens. While DM usually expresses S100 protein and SOX10, DM is almost always negative for MelanA/Mart1 and HMB45/GP100. At times, S100 immunostaining can be useful in defining the extent of DM.

In 2005, it was proposed that DM should be sub-classified into 'pure' DM and 'mixed' DM, on the basis that the subclasses exhibit differing clinical behaviour.^{7–9} Those with a $\geq 90\%$ DM component were defined as 'pure' DMs, while 'mixed' DMs were those comprising $>10\%$ and $<90\%$ DM. Close to 50% of all DMs are pure DMs.^{3–5,10–13} In a review of 252 DMs, Murali *et al.*¹¹ showed that pure DMs differ significantly from mixed DMs in location, Clark level of invasion, Breslow thickness, mitotic rate, perineural invasion and locoregional recurrence rate. A lower rate of distant metastasis with pure DM and better survival have been demonstrated in some series^{5,7,8,10} but not in others.^{11,14} One study compared survival in 117 patients with pure DM with 2273 cases of superficial spreading melanoma and found significantly improved melanoma-specific survival for pure DM after adjusting for other variables (HR 0.49, $P = 0.01$)¹⁵.

Clinically, melanomas that are predominantly desmoplastic usually present as firm plaques, nodules or areas of thickening and are often not pigmented unless there is a lentigo maligna in the overlying epidermis (present in approximately 50% of cases).¹⁶ The frequently unremarkable clinical appearance often leads to delayed diagnosis; consequently, DMs tend to present at a more advanced clinical stage of disease than other melanoma subtypes.^{17,18} The mean and median thickness of DMs is substantial – around 4.0 mm (2.0–6.5 mm) in reported series,^{2–5,10–14,17,19,20} and the majority of DMs have invasion to Clark level IV or V.

DMs are strongly associated with sun exposure and most frequently arise in the head and neck region.^{2,4,10,13,14,20,21} In one large study of scalp melanomas, 29% were desmoplastic.²² DMs are more common in males (M:F 2:1) and in older patients

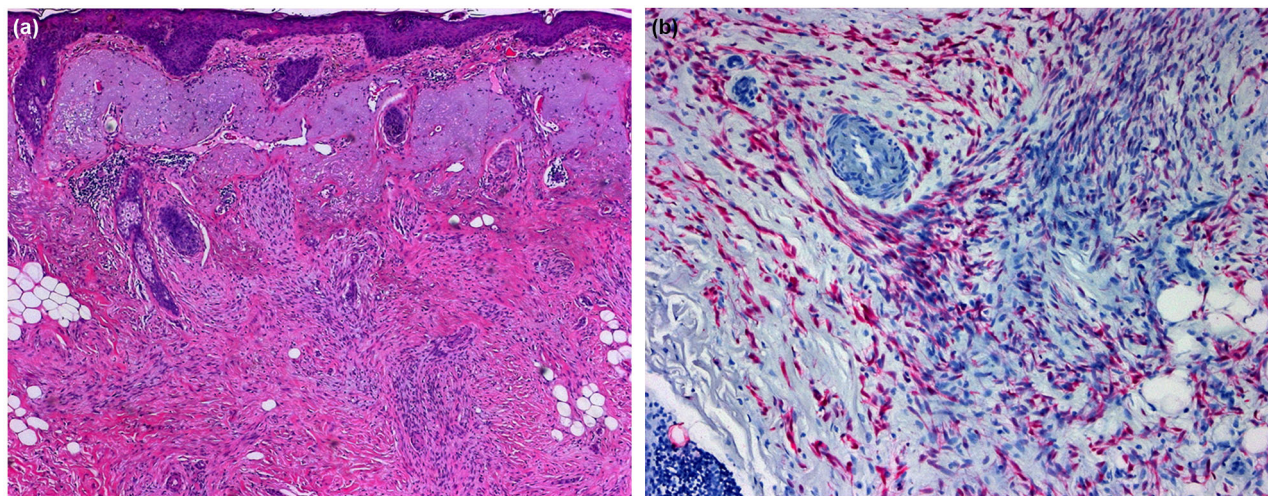


Figure 1 Desmoplastic melanoma on the ear of a 70-year-old female. (a) The dermis is expanded by a cellular infiltrate of pleomorphic spindle-shaped melanoma cells associated with fibrotic stroma (desmoplasia). There is marked solar elastosis in the dermis superficial to the tumour. (b) The melanoma cells are highlighted by strong positive staining for S100 (nuclear and cytoplasmic).

(median age 60–70 years) compared with patients with non-DMs (median age 50 years).^{2–5,10–14,20,23,24}

Cutaneous melanoma is known to have a much higher number of mutations than most other cancers, attributed to the role of sunlight exposure in its aetiology.²⁵ Of all melanoma subtypes, DM is the most likely to arise on severely sun-damaged skin and, consistent with this, recent evidence indicates that DM has the highest mutation burden of any melanoma subtype.²⁶ The high mutation burden is probably why metastatic DM responds particularly well to immunotherapy²⁷. Similarly, the driver mutations associated with DM differ from those more commonly seen in other types of cutaneous melanoma. Frequently mutated genes in DM include: *NF1*, *ERBB2*, *MAP2K1*, *MAP3K1*, *EGFR*, *MET*, *TERT*, *NFKBIE*, *PIK3CA* and *PTPN11*.²⁶ *BRAF* and *NRAS* mutations are less frequent than in other melanoma subtypes.

Neurotropism in desmoplastic melanomas

DM has a propensity for neurotropism. Neurotropism usually involves tumour invasion into and along nerves perineurally or endoneurally. Rarely the tumour cells themselves may form structures resembling nerves and some regard this as a form of neurotropism. In the great majority of cases, however, neurotropism takes the first of these forms (perineural or endoneural tumour invasion, with perineural invasion more common). DMs with neurotropism are designated desmoplastic neurotropic melanomas (DNMs).^{2,28,29} Neurotropism is seen in 30–60% of DMs^{3,4,7,11–14,21,30} and is found most frequently in pure DMs. Occasionally, large named nerves can be involved, an issue that can be particularly difficult to manage clinically when there is tumour extension along cranial nerves and their branches from a cutaneous primary site on the head or neck towards the base of the skull.¹⁴

It is important to note that neurotropism is not exclusive to DMs. Up to 30% of neurotropic melanomas are not DMs.²⁹ Varey *et al.*²⁹ reported a series of neurotropic melanomas in which 191 of 671 cases (28%) were not DMs. Some evidence suggests that there may also be a higher incidence of neurotropism in acral melanomas, where it is reported in up to 8% of cases.^{31,32}

Surgical management of desmoplastic melanoma: margins of excision

Early reports of DM highlighted a very high risk of local recurrence, ranging from 25% to 60%^{17,33–35} and suggested the need for more aggressive local treatment than for non-DMs, with wider margins and the use of adjuvant radiotherapy (RT) to reduce the risk of local recurrence.¹⁹ More contemporary studies do not show such an alarmingly high rate of local recurrence.^{2,4,12–14,21} Nevertheless, the local recurrence rate for DM in these later studies (6–15%) is still higher than for non-DM (<5%).⁴ The high rate of local

recurrence reported in early studies related to incomplete or close resection margins in most of the patients who recurred locally.^{12,14,29} Neurotropism has not been demonstrated to be a significant independent risk factor for local recurrence in most studies of DM,^{11,12,14,17,19,29,34,36} nor in studies of non-DM.^{29,32} The reported relationship between subtype of DM (pure vs. mixed) and the risk of local recurrence is variable, with some studies showing a higher risk of local recurrence for pure DM compared with mixed DM,^{10,11} but others showing no difference in risk.^{5,14}

To date, no prospective randomized clinical trials have specifically examined the appropriate clinical or histological margins required to minimize the risk of local recurrence in patients with DM.

Local recurrence associated with DM as the initial site of recurrence is associated with a high rate of development of distant metastases, as it is with melanomas in general. Guadagnolo *et al.*¹⁴ reported that 19 of 130 patients (15%) with DM developed local recurrence, and 15 of the 19 developed the local recurrence as the first site of recurrence. Of these, 9 (60%) went on to develop distant metastases. Similarly, Maurichi *et al.*¹⁰ reported subsequent distant metastasis in 22 of 37 patients (59%) with local recurrence.

Varey *et al.* reported no effect on local recurrence rates for neurotropic melanomas irrespective of whether the neurotropism occurred in association with DM or non-DM.^{29,37} There was, however, a significant relationship between inadequate histological margins (<2 mm vs. ≥8 mm) and local recurrence for all neurotropic melanomas. Multiple studies have shown that local recurrence is strongly related to involved definitive resection margins.^{2,12,14,29}

In summary, if adequate histological margins are achieved, there is no evidence that DM is associated with a higher rate of local recurrence compared with non-DM. Further, there is no evidence supporting the suggestion that excision margins for DM or neurotropic DM should differ from those recommended for other melanoma subtypes.

Adjuvant treatment of the primary site: radiotherapy

No randomized controlled trials addressing the potential benefit of adjuvant radiotherapy (RT) for DM or neurotropic melanoma have been published. However, Varey *et al.*²⁹ found in their retrospective study of neurotropic melanomas that RT (given to 82 patients) halved the risk of local recurrence if histological margins were <8 mm, with no difference between DM and non-DM.

Guadagnolo *et al.* found a significant reduction in the local recurrence rate in 130 DM patients treated with adjuvant RT. On subset analysis in this study, no benefit was observed with RT for DMs with no evidence of neurotropism, or mixed DMs.¹⁴

Oliver *et al.* also reported better local control in a small subset of DM patients who received adjuvant RT. There was no local recurrence in 10 patients treated with surgery and RT, but recurrence occurred in 10 of 85 patients (12%) who were initially treated with surgery alone ($P = 0.59$).⁴ Strom *et al.*¹² reported results for 277 DM patients with a median follow-up of 43 months. The overall local recurrence rate was 13%. There was a very substantial benefit for adjuvant RT if resection margins were reported to be histologically involved (5-year actuarial local control 89% vs. 18%, $P = 0.003$) and a reduced local recurrence rate with adjuvant RT for head and neck primaries with negative margins (local control 95% vs. 76%, $P = 0.03$). It was concluded that two subsets of patients with DM and clear resection margins could safely have adjuvant RT omitted (i) those with non-head and neck site and ≤ 4 mm thick; (ii) those with no neurotropism and ≤ 4 mm thick.

Chen *et al.*² reviewed 128 patients with DNM. Twenty-seven of the patients received adjuvant RT, 26 with primaries in the head and neck region, often with an excision margin < 5 mm. Local control rates in the adjuvant RT group were similar to the surgery-only group. It was concluded that adjuvant RT can produce local control rates similar to those produced by adequate surgical excision, when the latter cannot be achieved.

Sentinel node biopsy for desmoplastic melanoma

Regional lymph node involvement rates have been reported to be lower in DMs than in non-DMs, and as a result, standard recommendations pertaining to sentinel node biopsy (SNB) for the staging of primary cutaneous melanoma may not be applicable.

Dunne *et al.*³⁸ published a systematic review of 16 case series that reported the SN status of 1519 patients with DM. The SN-positivity rate was 6.5%, compared with an expected rate of 15–20% for non-DMs, and was significantly lower for pure DMs (5.4%) compared with mixed DMs (13.8%). The authors proposed that SNB should be considered for patients with mixed DM, as it would be for non-DM, but not for those with pure DM. However, the NCCN guidelines³⁹ advise that a SN-positivity rate of $> 5\%$ warrants consideration of SNB. Furthermore, an initial partial biopsy may indicate pure DM with the final resection showing mixed DM, leading to the erroneous omission of a SNB at the time of complete resection if a policy of not performing SNB for pure DM is adopted. In a recently published, evidence-based online tool for estimating the likelihood of SN positivity, the risk is considerably lower for pure DMs, but the presence of other predictive clinicopathological risk factors⁴⁰ often results in an estimated risk of SN positivity exceeding 5% by a considerable margin.

Systemic therapy for advanced stage metastatic desmoplastic melanoma

DM has one of the highest mutation burdens of any tumour.²⁶ The high mutation burden is probably why metastatic DM

responds particularly well to immunotherapy.²⁷ Driver mutations in *BRAF* and *NRAS* are uncommon in DM; hence, targeted therapy with a MAPK inhibitor is rarely indicated.

Current national and international treatment guidelines for desmoplastic and desmoplastic neurotropic melanomas

Twenty-nine published guidelines were identified that appeared to be the most recent originating from specific guideline groups.

The clinical management information detailed earlier is reflected in most melanoma guidelines from around the world, but some contain recommendations that do not appear to be evidence-based. Eleven guidelines provide specific advice for the management of DM and DNM,^{39,41–50} seven simply suggest reporting the subtype in the pathology report,^{51–57} and 11 do not address the management of DM as a separate entity.^{41,58–67} The guidelines that do provide advice base their recommendations on low-level evidence (case series) or low-level evidence in combination with expert consensus.

The recommendations made in published guidelines in relation to the management of DM and DNM, where they exist, are documented in Table 1, together with the levels of evidence on which they are based. Where the management of DM and DNM is specifically mentioned and the supporting levels of evidence are satisfactory, there is generally little disagreement in the guideline recommendations. These are summarized as follows:

1 Pathological reporting

Nine guidelines recommend that if a melanoma is of the desmoplastic subtype, this should be noted in the pathology report.^{39,42,48,50,52–54,56,68} Two guidelines state that it is important for the reporting pathologist to distinguish between pure and mixed DM.^{39,52} Seven guidelines advise that the presence of neurotropism should be reported.^{42,48,51,53–55,57}

2 Excision margins

Only three guidelines make specific recommendations about excision margins for DM.^{44,47,49} The Norwegian guidelines recommend excision margins of 2–3 cm, even for DMs only 1–2 mm in Breslow thickness,⁴⁷ but there is no evidence supporting this recommendation. The evidence-based South African and Australian guidelines specifically recommend using the same margins for DM as for non-DM, based on Breslow thickness.^{44,49}

3 Adjuvant radiotherapy

Six guidelines state that if excision margins are considered to be inadequate, adjuvant radiotherapy to the primary site is recommended for DMs and neurotropic melanomas, to improve local tumour control.^{39,43,44,48,50,68} However, what constitutes an inadequate margin is specified only in the Australian guidelines (< 8 mm pathological margin)⁴⁴ and the German guidelines (< 1 cm).⁵⁰ Adjuvant postexcision radiotherapy for DMs and neurotropic melanomas, not limited only to those with narrow or inadequate margins, is recommended in three guidelines.^{42,69,70} American Academy of Dermatology guidelines

Table 1 International clinical guidelines relating to diagnosis and treatment of desmoplastic melanoma, including neurotropic melanoma

Guideline group	Country	Year	Recommendation related to desmoplastic or neurotropic melanoma	Level of evidence	Grade of recommendation
European Dermatology Forum (EDF), the European Association of Dermato-Oncology (EADO) and the European Organization for Research and Treatment of Cancer (EORTC) ^{55,71}	Europe	2020	1 For the pathology report... additional information can be provided, including: vascular or perineural involvement	Not stated	Not stated
		2020	None	–	–
Japanese Dermatological Association ⁷²	Japan	2020	None	–	–
American Academy of Dermatology ⁴⁸	USA	2019	1 Optional features for inclusion in the pathology report; a Histological subtype (including desmoplastic) b Neurotropism/perineural invasion	II (Limited quality patient-oriented evidence)	B (based on inconsistent or limited quality patient-oriented evidence)
		2	2 Adjuvant radiotherapy after wide excision may be used for desmoplastic cutaneous melanoma with high-risk features (e.g. Breslow thickness >4 mm, Clark level V, extensive neurotropism/perineural invasion, head and neck location and/or narrow deep margin resection).	III (Other evidence, including consensus guideline, opinion, case studies) II/III	C (Recommendation based on consensus, opinion, case studies, or disease-oriented evidence) B
Cancer Council Australia ⁴⁴	Australia	2019	1 Desmoplastic melanomas and neurotropic melanomas should be excised with the same margins as non-desmoplastic/neurotropic melanomas of the same Breslow thickness.	IV (case series)	Not stated
		2	2 Adjuvant radiotherapy to the primary excision site should be considered for patients with desmoplastic or neurotropic melanomas for whom adequate (≥8 mm) pathological resection margins are not achieved.	IV (case series)	Not stated
Cancer Care Ontario ⁷³	Canada	2019	3 Sentinel lymph node biopsy (SLNB) should be considered for patients with desmoplastic melanoma, as it would be for non-desmoplastic melanoma.	III-1 (systematic review of case series)	Not stated
		2019	None	–	–
European Society of Medical Oncologists ⁶⁷	Europe	2019	None	–	–
		2019	1 Histopathological peculiarities... (e.g. desmoplastic melanoma parts) and vascular intrusions should, if available, be optionally included	0 (Expert consensus)	0 (open recommendation)
Deutsche Krebsgesellschaft, Deutsche Krebshilfe, AWMF ⁵⁰	Germany	2019	2 In the case of desmoplastic melanomas that have not been resected with a sufficient safety margin (<1 cm or R1 / R2), postoperative radiotherapy should be carried out to ensure local tumour control.	2b (Individual cohort study)	B (Should recommend)
		2019	Non-core (recommended) elements for pathology reporting include melanoma subtype (including desmoplastic melanoma)	Not stated	Not stated
International Collaboration on Cancer Reporting (ICCR) ^{37,56}	USA, Canada, Australia, UK, Europe	2019	None	Not stated	Not stated

Table 1 Continued

Guideline group	Country	Year	Recommendation related to desmoplastic or neurotropic melanoma	Level of evidence	Grade of recommendation
National Comprehensive Cancer Network ³⁹	USA	2019	1 Adjuvant radiation may be considered for selected cases of high-risk desmoplastic melanoma with close margins when re-resection is not feasible and/or with extensive neurotropism	2B (low-level evidence, non-uniform consensus)	Not stated
			2 Encourage consistent reporting of; pure desmoplastic, if present, or specify pure vs. mixed desmoplastic with spindle cell and/or epithelioid cells	2A (Lower level evidence, uniform consensus)	Not stated
			3 When pure desmoplastic melanoma is suspected, multidisciplinary consultation including an experienced dermatopathologist is recommended for determining staging and treatment options.	2A	Not stated
			4 The role of SLNB in patients with pure desmoplastic melanoma 2A is controversial. Clinicians may consider forgoing SLNB in patients with confirmed pure desmoplastic melanoma		Not stated
National Health Commission of the People's Republic of China ⁵⁷	China	2018	A histopathological report of primary skin melanoma should contain. . . . neurotropism	Not stated	Not stated
Association of Italian Medical Oncologists ⁵¹	Italy	2018	Presence of neurotropism should be part of a standard pathology report.	Not stated	Not stated
Norwegian Health Directorate ⁴⁷	Norway	2018	For Breslow thickness >4 mm and desmoplastic lesions; excision with 2–3 cm excision width (<i>in vivo</i>) margins	2b (knowledge based on at least one other well-designed quasi-experimental study without randomization)	Not stated
Finnish Melanoma Group ⁴⁵	Finland	2018	Indications for adjuvant therapy; large desmoplastic melanoma	Not stated	Not stated
Croatian Society for Medical Oncology ⁶⁴	Croatia	2017	None	–	–
French Dermatology Society and French National Federation of Comprehensive Cancer Centres, French National Cancer Institute ⁶³	France	2017	None	–	–
Scottish Intercollegiate Guidelines network (SIGN) ⁵²	Scotland	2017	It is important to distinguish between pure and mixed subtypes of desmoplastic melanoma. Pure DM is thought to be associated with a more favourable outcome and lower incidence of a positive SLNB	Not stated	Not stated
Clinicians at University hospitals in Spain ⁴³	Spain	2017	Histogenic type should be included in the pathology report Adjuvant radiotherapy is rarely necessary for excised local melanoma and can be considered for inadequate resection margins in lentigo maligna, and desmoplastic neurotropic melanoma	2b (Time series comparisons or dramatic results from uncontrolled studies)	B (not explained)
University Hospital clinicians (Zurich, Bern, Lausanne, Basel) ⁶⁰	Switzerland	2016	None	–	–

Table 1 Continued

Guideline group	Country	Year	Recommendation related to desmoplastic or neurotropic melanoma	Level of evidence	Grade of recommendation
Dutch Societies of Radiology, Dermatology and Venereology, Pathology, Surgery, Internal Medicine and Radiology ⁶¹	Netherlands	2016	None	–	–
Central Oncology Institute, Warsaw ⁶⁸	Poland	2016	1 Features conditionally specified in the histopathological report: histological subtype ... other types, e.g. desmoplastic	Not stated	Not stated
			2 Indication for complementary radiotherapy after primary tumour resection the following factors may be: desmoplastic melanoma cut with narrow margins, positive surgical margins (especially after excision local recurrence) ... Increased neurotropism	Not stated	Not stated
UK National Disciplinary guidelines for head and neck cancers ⁵⁸	United Kingdom	2016	None	–	–
Brazilian Dermatological Society ⁵⁹	Brazil	2015	None	–	–
National Collaborating Centre for Cancer ⁶⁵	United Kingdom	2015	None	–	–
Danish Melanoma Group ⁶³	Denmark	2014	Neurotropism should be stated in the histopathology report	Not stated	Not stated
State expert Centre of Ministry of Health of Ukraine, National Cancer Institute of the Ministry of Health of Ukraine ⁴²	Ukraine	2015	1 Histopathology report should state desmoplastic with or without neurotropism	Not stated	Not stated
		2	Adjuvant radiotherapy after surgery can be considered to improve local control	Non-randomized comparison	Not stated
Melanoma Cancer Site Team ⁶²	Canada	2013	None	Not stated	Not stated
Provincial Melanoma Treatment Guidelines ⁴¹	Canada	2012	Adjuvant radiotherapy to the primary site can be considered to reduce local recurrence in the following conditions: Melanomas with desmoplastic or neurotropic features.	Not stated	Not stated
British Association of Dermatologists ⁵⁴	United Kingdom	2010	Desmoplastic melanoma with or without neurotropism should be recorded because of its different biological behaviour and clinical outcome	Case series	Not stated
Melanoma Advisory Board (consisting of dermatologists, oncologists, plastic surgeons and pathologists) ⁴⁹	South Africa	2004	1 Wider excision than is normal for other histological types of melanoma is recommended for desmoplastic melanoma	Two case series	Not stated
		2	Postoperative radiotherapy in consultation with a specialist should be considered after surgical excision of recurrent desmoplastic or neurotropic melanoma		

recommend radiotherapy for patients with DM treated with narrow margins or high-risk features such as Breslow thickness >4 mm,⁴⁸ and South African guidelines suggest that adjuvant radiotherapy be used for recurrent desmoplastic or neurotropic melanomas.⁴⁹

4 Sentinel node biopsy

Guidelines differ in their recommendations for SN biopsy in patients with DM. Since the SN-positivity rate is substantially lower for pure DM (5.4% in a systematic review),³⁸ some guidelines (e.g. NCCN³⁹) suggest that forgoing SN biopsy for confirmed pure DM may be considered, regardless of tumour thickness and ulceration status. Based on assessment of the available evidence, the Australian guidelines suggest that it should be considered using the same criteria as would be applied for non-DM.⁴⁴ However, uncertainty is reflected by the suggestion in both the NCCN and Australian guidelines that there should be discussion about the value of SNB for patients with DM on a case-by-case basis by a multidisciplinary team.^{39,44} A recommendation for SNB for an individual patient will be based not only on the estimated SN-positivity rate (which can be obtained from a validated nomogram),⁴⁰ but also on the patient's comorbidities, and whether knowledge of SN status will change their management.

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Author contribution

All authors substantially contributed to the manuscript.

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