Research Square

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Limb melanoma management in a resource-limited North African setting: surgical margins, reconstruction, and survival

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Abstract

Background: Acral melanoma is the predominant subtype of limb cutaneous melanoma in North African populations, presenting unique surgical and recon- structive challenges. Plastic surgeons play a central role in achieving oncological clearance while preserving limb function. In resource-limited settings, the absence of sentinel lymph node biopsy (SLNB) influences staging and management strategies.

Methods: We conducted a 10-year retrospective study (2012–2021) at the Department of Plastic, Reconstructive and Aesthetic Surgery, Habib Bourguiba University Hospital, Tunisia. Adult patients with histologically confirmed limb melanoma were included. Data on demographics, tumor characteristics, sur- gical and reconstructive management, adjuvant therapy, and outcomes were collected. Overall survival (OS) and disease-free survival (DFS) were analyzed using Kaplan–Meier method.

Results: Thirty patients (15 men, 15 women; mean age 63.9 ± 19.1 years) were included. Acral lentiginous melanoma accounted for 50% of cases, predominantly affecting the plantar surface. Median diagnostic delay was 12 months. Mean Breslow thickness was 6.1 mm. Wide local excision achieved R0 margins in 73.3%, while amputation was necessary in 16.6%. Five-year OS and DFS were 39% and 22.2%, respectively.

Conclusion: Limb melanoma in Tunisia is characterized by late diagnosis, advanced tumor thickness, and a high prevalence of acral subtypes. Plastic surgeons play a pivotal role in balancing oncological safety and functional preser- vation. Early detection, adherence to surgical guidelines, and multidisciplinary management are essential to improve outcomes in resource-limited settings.

1 Introduction

Cutaneous melanoma (CM) has emerged as a major global public health concern, characterized by a steadily increasing incidence over the past few decades [1], [2]. While the epidemiological landscape and therapeutic innovations are extensively

documented in Western countries, data remains scarce in North Africa.

In Tunisia, limb melanomas represent a significant clinical challenge, often occur- ring in a specific socio-epidemiological context where acral lentiginous melanoma (ALM) is disproportionately prevalent compared to European cohorts [3], [4]. These lesions, frequently located on the soles of the feet or palms, are associated with distinct biological aggressiveness and a documented poor prognosis in regional studies [5].

The management of limb melanoma involves complex clinical and surgical dilem- mas. The inherent anatomical constraints of the extremities, such as limited skin laxity and proximity to vital neurovascular structures, often hinder the achievement of radical excision margins, which are essential for local control [6].

This complexity is further exacerbated in Tunisia by significant diagnostic delays, leading to advanced presentations with thick, ulcerated tumors. Such cases often necessitate extensive resections that threaten limb function, mobility, and aesthetics, or even require life-altering amputations. Despite the integration of modern sys- temic therapies [7], [8], surgical intervention remains the primary curative modality. However, there is currently a lack of specialized literature in Tunisia focusing on reconstructive strategies and surgical outcomes specifically within the discipline of plastic surgery.

This study aims to address this knowledge gap by providing a comprehensive analysis of a cohort of 30 patients managed in a Tunisian Plastic Surgery Depart- ment. We investigate the epidemiological, clinical, and histopathological specificities of limb CM in this population.

By focusing on surgical margin management, diverse reconstructive techniques, ranging from skin grafts to specialized flaps, and long-term prognostic factors, this work seeks to define an evidence-based surgical approach tailored to resource-limited settings. Ultimately, we highlight the indispensable role of the plastic surgeon in the multidisciplinary management required to optimize both oncological safety and functional recovery.

2 Materials and Methods

2.1 Study Design and Setting

A retrospective, single-center cohort study was conducted at the Department of Plas- tic, Reconstructive and Aesthetic Surgery, Habib Bourguiba University Hospital, Sfax, Tunisia.

The study period spanned ten years, from January 1, 2012, to December 31, 2021. This department serves as a regional referral center for complex oncological reconstructions.

2.2 Inclusion and Exclusion Criteria

Inclusion criteria: All patients aged 18 years or older who were diagnosed with histolog- ically confirmed cutaneous melanoma localized to the upper or lower limbs (including the shoulder and gluteal regions) and underwent surgical treatment at our department during the study period.

Exclusion criteria: Patients with incomplete medical records, those lost to follow-up immediately after diagnosis, and those with melanoma arising from non-cutaneous sites (e.g., mucosal, ocular) or located outside the limbs.

2.3 Data Collection

Data were extracted from hospital medical records, operative reports, pathology databases, and outpatient clinic files using a standardized, piloted data collection form. To ensure a comprehensive analysis, data were systematically collected using a standardized abstraction form. The variables were categorized into five main domains: patient demographics, clinical characteristics, detailed histopathological findings, surgical and adjuvant treatment modalities, and long-term follow-up outcomes.

This structured approach allowed for a rigorous evaluation of both the oncological and reconstructive aspects of limb melanoma management. The full framework of the recorded parameters is detailed in Table 1.

Table 1 Variables recorded for data collection

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Category	Variables Recorded
Demographics	Age, sex, geographical origin (urban/rural), and occupation.
Clinical Presentation	Symptom duration (diagnostic delay), lesion location, tumor size (maximum diameter), clinical morphology, presence of ulceration, and status of palpable lymph nodes.
Histopathology	Histological subtype, Breslow thickness (mm), Clark level, pathological ulceration, mitotic rate (mitoses/mm^2), lymphovascular invasion (LVI), and perineural invasion (PNI).
Surgical Management	Date of diagnosis, type of surgery (wide local excision vs. amputation), surgical margin width (cm), resection status (R0/R1/R2), and reconstructive method (direct closure, skin graft, or flap).
Lymph Node & Adjuvants	Performance and extent of lymph node dissection (LND), and administration of adjuvant therapies (radiotherapy, chemotherapy, or immunotherapy).
Follow-up & Outcomes	Date of last contact, disease status (remission, local recurrence, nodal recurrence, or distant metastasis), date of death, and cause of death (if applicable).

2.3.1 Surgical and Reconstructive Protocol

Patient management was standardized through a monthly multidisciplinary tumor board (established in 2014) comprising surgical and medical oncology specialists. Sur- gical intervention focused on wide local excision, aiming for oncological clearance with margins tailored to Breslow thickness, though often adapted to anatomical limb con- straints.

In the absence of sentinel lymph node biopsy (SLNB) facilities, therapeutic lymph node dissection was performed only for clinically or radiologically suspicious nodes. Reconstruction followed a stepwise approach, prioritizing functional recovery through primary closure, skin grafting, or local fasciocutaneous and muscle flaps, depending on defect requirements.

This management strategy reflects real-world clinical practice in a low- and middle-income setting, where access to SLNB and advanced oncological resources remains limited.

2.3.2 Outcome Measures

Primary outcomes were overall survival (OS), defined as the time from histological diagnosis to death from any cause, and disease-free survival (DFS), defined as the time from completion of primary treatment to first recurrence (local, regional, or distant) or death. Secondary outcomes included rates of local recurrence, nodal metastasis, distant metastasis, and types of reconstructive procedures.

2.4 Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version

23.0 (Armonk, NY: IBM Corp).

Continuous variables were expressed as mean ± standard deviation (SD) or median with range, as appropriate.

Categorical variables were expressed as frequencies and percentages. Survival curves were generated using the Kaplan–Meier method and compared using the log-rank test. A p-value of ¡0.05 was considered statistically significant. Due to the sample size, multivariate analysis was not performed.

3 Results

3.1 Patient and Tumor Characteristics

Thirty patients were included in this monocentric cohort of limb cutaneous melanoma. The population was predominantly elderly, with most patients aged over 60 years, and a marked predominance of rural residence, reflecting the referral profile of our insti- tution. Clinically, melanoma primarily involved the lower limb, with plantar lesions representing

the most frequent location. Diagnostic delay was substantial, with more than half of patients consulting beyond one year after symptom onset.

Histopathological analysis revealed a predominance of acral lentiginous melanoma, consistent with the anatomical distribution observed. As illustrated in Figure 1, yumors were generally diagnosed at an advanced stage, characterized by marked tumor thickness and a high frequency of ulceration. Most patients presented with localized but thick disease (AJCC stage II), while a significant proportion already had regional nodal involvement at diagnosis. Detailed demographic, clinical, and pathological characteristics are summarized in Tables 2 and 3.

Table 2 Baseline demographic, clinical and histopathological characteristics of the study cohort (n= 30)

Category	Variable	Value
Demographics	Age, mean ± SD (years)	63.9 ± 19.1
	Age > 60 years, n (%)	18 (60.0)
	Sex (male / female), n	15 / 15
	Rural residence, n (%)	22 (73.3)
	Agricultural occupation, n (%)	16 (53.3)
Clinical characteristics	Primary site – lower limb, n (%)	27 (90.0)
	Plantar location, n (%)	18 (60.0)
	Upper limb involvement, n (%)	3 (10.0)
	Median consultation delay (months)	12
	Delay > 12 months, n (%)	17 (56.6)
	Median tumor diameter (mm) [range]	29.1 [10–70]
	Main clinical morphology	Ulcero-nodular
Histopathology	Histological subtype, n (%)	
	— Acral lentiginous melanoma (ALM)	15 (50.0)
	— Nodular melanoma (NM)	9 (30.0)
	— Superficial spreading melanoma (SSM)	3 (10.0)
	— Others / unclassified	3 (10.0)
	Breslow thickness, mean (range), mm	6.1 (0.1–20.0)
	Breslow > 4 mm (pT4), n (%)	15 (50.0)
	Pathological ulceration, n (%)	19 (63.3)
	Clark level IV–V, n (%)	18 (60.0)
	Mitotic rate > 5/mm^2, n (%)	11 (36.7)
	Lymphovascular invasion, n (%)	9 (30.0)
	Perineural invasion, n (%)	7 (23.3)
	AJCC 8th edition stage II–III, n (%)	28 (93.4)

3.2 Histopathological Risk Profile

Overall, the cohort demonstrated a high-risk histopathological profile. In addition to increased Breslow thickness, deep dermal invasion was common, and aggressive pathological features such as ulceration, elevated mitotic activity, lymphovascular invasion, and perineural invasion were frequently observed.

Table 3 Surgical management, reconstruction techniques and postoperative outcomes

Category	Variable	n (%)
Primary surgery	Wide local excision	30 (100)
	Surgical margin ≥ 2 cm	21 (70.0)
	Amputation	6 (20.0)
	Partial foot amputation	4 (13.3)
Lymph node management	SLNB performed	0
	Therapeutic lymph node dissection	7 (23.3)
Reconstruction	Skin graft	12 (40.0)
	Local flap	8 (26.7)
	Regional flap	6 (20.0)
	Free flap	4 (13.3)
Postoperative course	Early complications (overall)	9 (30.0)
	— Wound infection	4 (13.3)
	— Partial graft/flap necrosis	3 (10.0)
	— Delayed healing	2 (6.7)
Hospital stay	Median length of stay (days)	7

These findings reflect biologically aggressive disease and are consistent with the advanced clinical presentation at diagnosis. The full distribution of histopathological parameters is detailed in Table 3.

3.3 Surgical Management and Reconstructive Outcomes

All patients underwent surgical excision with curative intent. Wide local excision achieved microscopically clear margins in the majority of cases; however, margin involvement remained a challenge in locally advanced tumors.

Reconstruction was required in most patients due to the size and location of post-excisional defects. As showing in Figure 2, while direct primary closure was feasible in selected cases, skin grafting constituted the most frequently employed reconstructive strategy, particularly for plantar and distal limb defects. Local flaps were reserved for carefully selected patients with weight-bearing or functionally critical areas.

Amputation was necessary in a subset of patients with extensive local invasion, highlighting the functional cost of achieving oncological clearance in advanced acral melanoma. Regional lymph node dissection was performed selectively in patients with clinically or radiologically suspicious nodes, in the absence of sentinel lymph node biopsy. Surgical and reconstructive details are presented in Table 3.

3.4 Oncological Outcomes and Survival Analysis

After a median follow-up of 28 months, overall mortality remained high, reflecting the advanced stage of disease at presentation. Median overall survival was four years, with limited long-term disease control observed across the cohort.

As illustrated in table 4, Survival analysis demonstrated a marked reduction in both overall and disease-free survival among patients presenting with advanced age, prolonged diagnostic delay, ulcerated tumors, involved surgical margins, and nodal metastasis, as presented in figure 3.

Conversely, patients achieving complete (R0) resection and those without nodal involvement exhibited significantly improved survival outcomes. Breslow thickness did not reach statistical significance as a prognostic factor, likely due to the predomi- nance of uniformly thick tumors within the cohort. Univariate survival analysis is summarized in Table 5.

Table 4 Oncological outcomes and survival

Outcome	Value
Median follow-up (months)	28
Local recurrence, n (%)	6 (20.0)
Regional nodal recurrence, n (%)	5 (16.7)
Distant metastasis, n (%)	9 (30.0)
Any recurrence, n (%)	14 (46.7)
Melanoma-related death, n (%)	11 (36.7)
2-year Overall Survival (OS)	63.3%
5-year Overall Survival (OS)	41.2%
2-year Disease-Free Survival (DFS)	52.0%
Median OS (months)	38

Table 5 Univariate analysis of prognostic factors for overall survival (n = 30)

Prognostic Variable	5-Year OS (%)	p-value CI]	(Log-rank)	[95%
Age (years)		0.031*		
≤ 60 years	58			
> 60 years	25			
Consultation Delay		0.017*		
≤ 12 months	54			
> 12 months	20			
Clinical Morphology		0.031*		
Non-ulcerated	55			
Ulcero-nodular	22			
Surgical Margin Status		0.006*		
R0 (Clear margins)	48			
R1 / R2 (Involved margins)	12			
Pathological Nodal Status (pN)		0.016*		
pN0 (Negative)	50			
pN+ (Positive)	18			
Breslow Thickness		0.102		
≤ 4 mm	47			
> 4 mm	28			

* Statistically significant at $p < 0.05$. OS: Overall Survival.

4 Discussion

4.1 Regional epidemiology of acral melanoma

This study highlights the particular epidemiological profile of acral melanoma in a North African population. In contrast to Western series, where superficial spreading melanoma predominates, acral lentiginous melanoma represented the most frequent histological subtype in our cohort [3], [4], [12] and [13].

The marked predominance of plantar involvement is consistent with reports from Africa, Asia, and other low- and middle-income regions, where acral sites constitute the main anatomical locations of melanoma [5], [11] and [13]. These findings support the

hypothesis that ethnic, genetic, and environmental factors contribute to distinct melanoma patterns across populations [16] and [17].

Key finding: Acral melanoma represents the dominant melanoma subtype in North African patients, with a clear predilection for plantar locations.

4.2 Diagnostic delay and advanced disease at presentation

A major finding of this study is the substantial diagnostic delay observed in most patients, frequently exceeding one year [19] and [23].

This delay likely explains the advanced tumor thickness, high ulceration rate, and frequent nodal involvement at diagnosis.

Several factors may contribute, including low public awareness, misinterpretation of plantar lesions as benign conditions, limited access to specialized dermatologic care, and delayed referral pathways [20] and[21]. Similar delays have been reported in other resource-limited settings, reinforcing the global challenge of early melanoma detection outside high-income countries [14] and [18].

Key finding: Delayed diagnosis remains a major determinant of advanced-stage acral melanoma and poor prognosis in resource-limited settings.

4.3 Surgical and reconstructive challenges

Surgical management of acral melanoma poses significant challenges due to the anatomical constraints of the hands and feet, particularly in weight-bearing areas [6],

[22] and [26]. In our cohort, achieving adequate oncological margins often required extensive resections, and amputation remained unavoidable in a subset of patients with locally advanced disease [29], [30].

Reconstruction strategies were tailored to defect size and functional requirements, with skin grafting representing the most commonly used option, while local or regional flaps were reserved for selected cases [27], [29]. These reconstructive choices reflect a balance between oncological safety, functional preservation, and available surgical resources.

Key finding: Acral melanoma frequently necessitates complex reconstructive deci- sions, with limb preservation often limited by late presentation and anatomical constraints.

4.4 Impact of resource limitations and socio-economic context

The absence of sentinel lymph node biopsy significantly influenced both staging and therapeutic strategies in this cohort [31]. Consequently, lymph node dissection was restricted to clinically or radiologically suspicious cases.

This pragmatic approach, although suboptimal compared with international guide- lines, reflects daily practice in many low- and middle-income countries [22], [31].

Moreover, socio-economic factors such as rural residence, occupational exposure, and limited healthcare access likely contributed to delayed diagnosis and advanced disease [3], [4], [19] and [21].

Despite these constraints, surgical management remained the cornerstone of treat- ment, underscoring the pivotal role of plastic surgeons in oncological care within such settings.

Key finding: Management strategies for acral melanoma must be adapted to local resource availability, with surgery remaining central in low-resource environments.

4.5 Prognostic implications

Survival analysis confirmed the strong prognostic impact of established factors, par- ticularly Breslow thickness and nodal involvement [41]. Patients presenting with thick tumors and clinically positive lymph nodes experienced significantly poorer overall and disease-free survival.

The limited prognostic discrimination of Breslow thickness within this cohort may be explained by the predominance of uniformly thick tumors, a pattern commonly observed in late-presenting populations. These findings reinforce the need for earlier detection to improve survival outcomes [9], [10],[36] and [37].

Key finding: Advanced tumor thickness and nodal involvement remain the strongest predictors of poor survival in acral melanoma.

4.6 Study limitations

This study has several limitations, including its retrospective design, small sample size, and the absence of sentinel lymph node biopsy and multivariate analysis. These factors may limit the generalizability of the findings and the strength of prognostic conclusions.

Despite these limitations, our study reflects daily surgical reality in North African plastic surgery units, providing valuable real-world data on the management of acral melanoma in resource-constrained environments.

5 Conclusion

This study provides a comprehensive analysis of limb cutaneous melanoma in a North African cohort, emphasizing the predominance of acral lentiginous melanoma and late-stage presentation.

Advanced tumor thickness, delayed consultation, and nodal involvement significantly impact survival, underscoring the need for early detection.

Plastic surgeons are crucial in achieving oncological clearance while preserving limb function, often navigating complex reconstructive decisions including skin grafts, flaps, and occasional amputation. In the absence of SLNB and limited access to systemic therapies, surgical management remains the cornerstone of care.

Key findings:

- Early detection campaigns and patient education are essential to reduce diagnostic delays.
- Reconstructive strategies must balance functional outcomes with oncological safety,

especially in plantar and acral lesions.

- Multidisciplinary tumor boards optimize patient outcomes in resource-limited environments.

Despite the retrospective, single-center design and absence of SLNB, this study reflects real-world surgical practice in North African plastic surgery units and provides valuable insights for improving management strategies in similar settings.

Declarations

6.1 Funding

Not applicable.

6.2 Ethics Statement

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. As a retrospective study based on anonymized medical records, formal ethics committee approval was not required at our institution. Patient confidentiality was maintained throughout data collection and analysis.

6.3 Clinical Trial Number

Not applicable.

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Figures

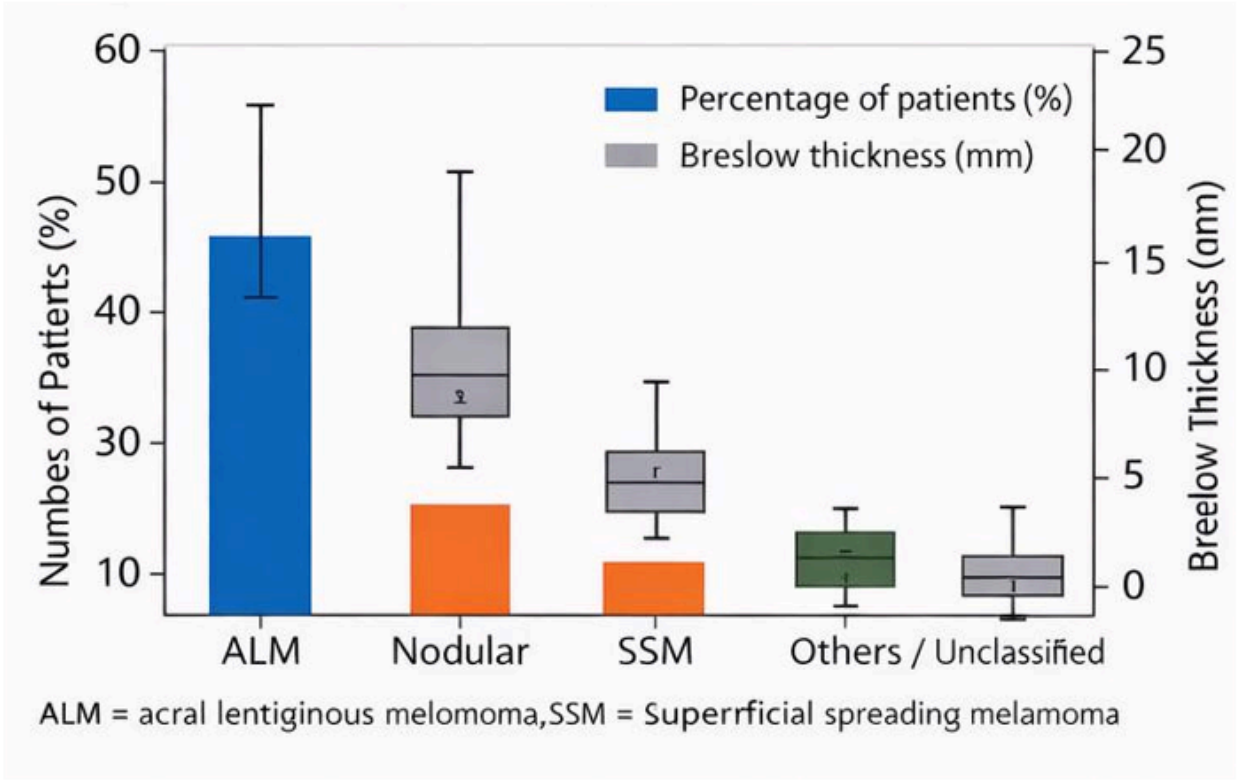


Figure 1

Histological Subtypes and Breslow Thickness

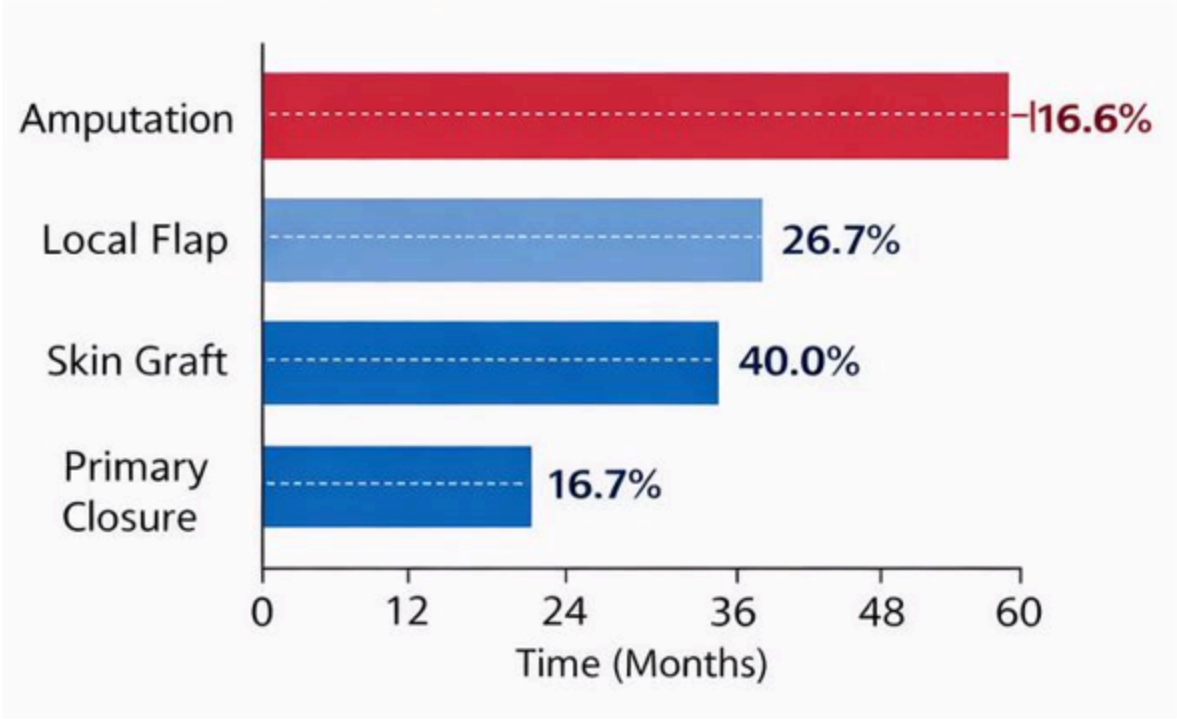


Figure 2

Reconstruction Technqiues and Amputation After Wide Excision

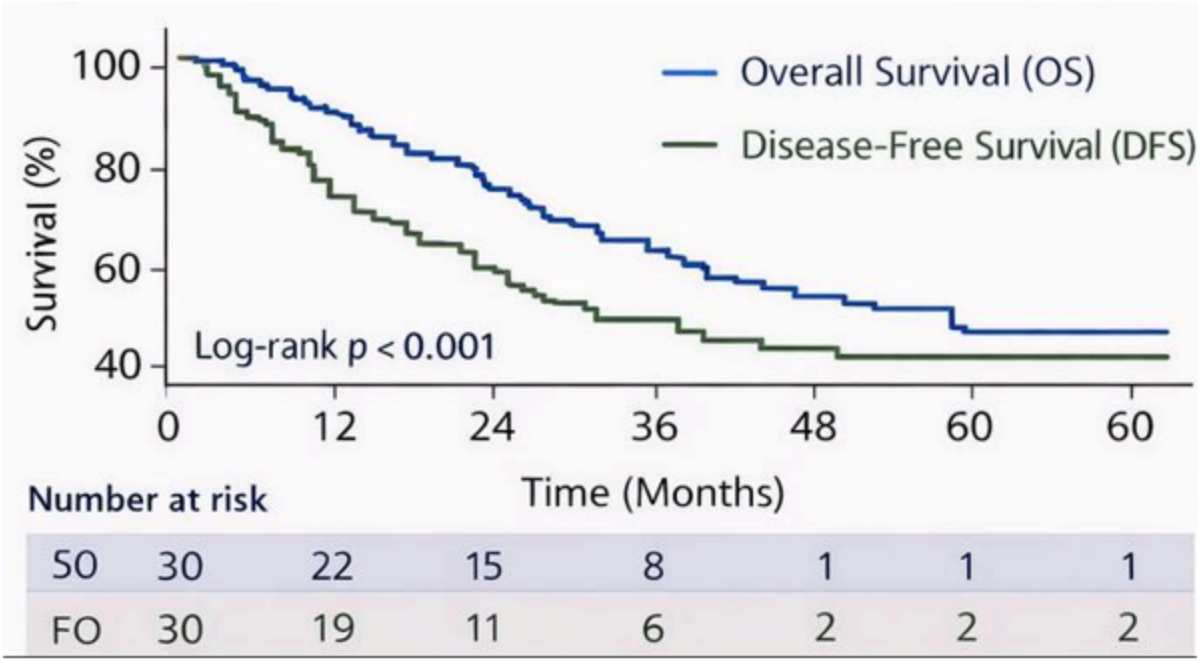


Figure 3

Kaplan-Meier Curves of Overall Sunivall (OS) and DFS