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Article

Reconstruction After Wide Excision of the Nail Apparatus in the Treatment of Melanoma

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Background/Objectives: Historically, the treatment of subungual melanoma (SUM) was based on amputation of the affected digit. However, extended wide local excision of nail apparatus (WLE) is now a conservative alternative for in situ or minimally invasive forms. There are many after WLE reconstruction techniques, but few studies have objectively compared their results. The objectives were to carry out a systematic review of after WLE reconstructions in the treatment of SUM and to present a series of cases operated on with objective evaluation. **Methods:** This systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations. An exhaustive search was carried out in the PubMed (Medline), Embase and Cochrane Library databases, from their creation to January 2025. Articles reporting reconstructions after WLE for SUM of the fingers or toes were included. Clinical, technical and outcome data were analyzed. A retrospective study of ten cases operated on between 2021 and 2024 was carried out, with clinical, surgical, functional and aesthetic data collected, as well as validated scores (Quick DASH, Modified Mayo Wrist Score, AOFAS). **Results** The literature review included 24 articles on 373 patients, mostly with in situ SUM. Reconstruction was most often performed using total skin grafts, sometimes combined with dermal matrices. Some authors used local or free flaps. Few studies used validated functional scores. Local recurrences were significant, affecting 18% of patients and requiring secondary amputation. In our series, all patients underwent WLE with reconstruction, using total skin grafts with or without dermal matrix, or local flaps. There were two recurrences. The functional and aesthetic results were satisfactory and objectively measured, with an average follow-up of 19 months. **Conclusion:** Nail apparatus reconstructions are primarily indicated for in situ or minimally invasive subungual melanomas. Immediate reconstruction carries a risk of performing the reconstruction over residual tumor tissue, particularly in the case of invasive melanomas. Reconstructive techniques, such as full-thickness skin grafts and the use of dermal matrices, can provide satisfactory functional and aesthetic outcomes. However, objective evaluations of these results remain limited, and better standardization of clinical practice, along with prospective studies, is needed to refine long-term outcome assessment.

Keywords: Subungueal Melanoma, Reconstruction, Wide local excision, nail apparatus

1. Introduction

Melanoma is a major public health concern, with over 330,000 new cases and more than 58,000 deaths per year worldwide by 2022 (1). It has now been established that one of the major prognostic factors for melanoma is the Breslow index, corresponding to the depth of invasion, measured in millimeters, of these lesions (2). Subungual melanomas (SUM) belong to the subcategory of acral-lentiginous melanomas, which represent approximately 0.7 to 3.5% of all types of melanomas in Caucasians, but sometimes up to 50% of melanomas in Asian or African-Caribbean subjects (3, 4). SUM is most frequently found in the nail matrix, where it manifests as a dark, heterochromatic, longitudinal melanonychia with ill-defined contours that can sometimes invade adjacent skin folds. Historically, treatment was based on systematic amputation of the affected digit, often resulting in significant functional defect and cosmetic damage, which had a considerable impact on quality of life (5). Today, it has been established that in situ or minimally invasive melanomas (Breslow thickness < 0.5 mm) can be treated conservatively, by wide local excision (WLE) of the nail apparatus (6-8). SUM involves excision of the entire nail with margins generally between 5 and 10 mm, and immediate or delayed reconstruction (9). The choice of reconstruction technique is complex and not consensual, particularly when the excision is large, local functional requirements are important, and scarring threatens to cause cosmetic damage with social repercussions (10, 11). In order to better identify the possibility of reconstruction, we firstly, carried out a systematic review of the literature on surgical techniques used in nail reconstruction following SUM. Secondly, we evaluated the reconstructions carried out in our center, by a single operator, of soft tissue defect caused by a WLE in the context of a SUM.

2. Materials and Methods

2.1 Literature review

To identify the main surgical techniques used and to assess whether a consensus exists, we conducted a systematic review of the literature on methods of reconstruction after extended excision of the nail apparatus in SUM of the upper and lower limbs.

- Literature search

This systematic review was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (12). An exhaustive search was conducted in the MEDLINE (PubMed), Embase and Cochrane Library databases, from their creation to January 2025. The keywords used were: ('Nail apparatus Melanoma' OR 'Nail Matrix Melanoma' OR 'Subungual Melanoma') AND ('reconstruction' OR "flap" OR 'dermal matrix' OR 'skin graft' OR 'healing'). A manual search for the bibliographies of relevant articles completed the analysis. Only articles in English and French were retained. After an initial screening of titles and abstracts, duplicates, irrelevant studies, literature reviews, animal studies and cases of amputation were excluded. The full texts were then analyzed, and purely anatomical studies were excluded. This research project has been approved by the institutional ethics committee.

- Complication risk factors: history of diabetes, smoking, major comorbidities.
- Tumor characteristics: Breslow index, sentinel lymph node status if present.

- Excision strategy: excision margins applied. 152
 - Reconstruction strategy: number of stages, reconstruction time, technique used, 153
operating time. 154
 - Post-operative follow-up: occurrence of any major complications (infection, hematoma, 155
failure of the reconstruction) or minor complications (early consultation, disunion, healing 156
problems, return to the operating theatre for secondary touch-up). 157
 - Duration of post-operative follow-up. 158
- Each patient was also asked to complete a functional evaluation questionnaire 159
at least 6 months after the last operation: 160
- Damage to the upper limb was assessed by the Quick DASH (score from 0 to 100) and 161
the Modified Mayo Wrist Score (score from 0 to 100). 162
 - Damage to the lower limbs was assessed using the AOFAS score (American Orthopedic 163
Foot and Ankle Score; score from 0 to 90). 164

3. Results 166

- Study selection 167

An initial search conducted in the PubMed and TRIP databases identified 593 articles. 168
After removing duplicates and excluding articles written in languages other than 169
French, English, or Spanish, 547 unique references were included for screening. Title and 170
abstract review led to the selection of 45 articles for full-text assessment. Of these, 21 171
were excluded: 16 focused on cases managed by amputation, one provided insufficient 172
data, and four dealt with acral lentiginous melanomas at unrelated anatomical sites. In 173
total, 24 studies met the predefined inclusion and exclusion criteria and were included 174
in the analysis (Figure 1). 175

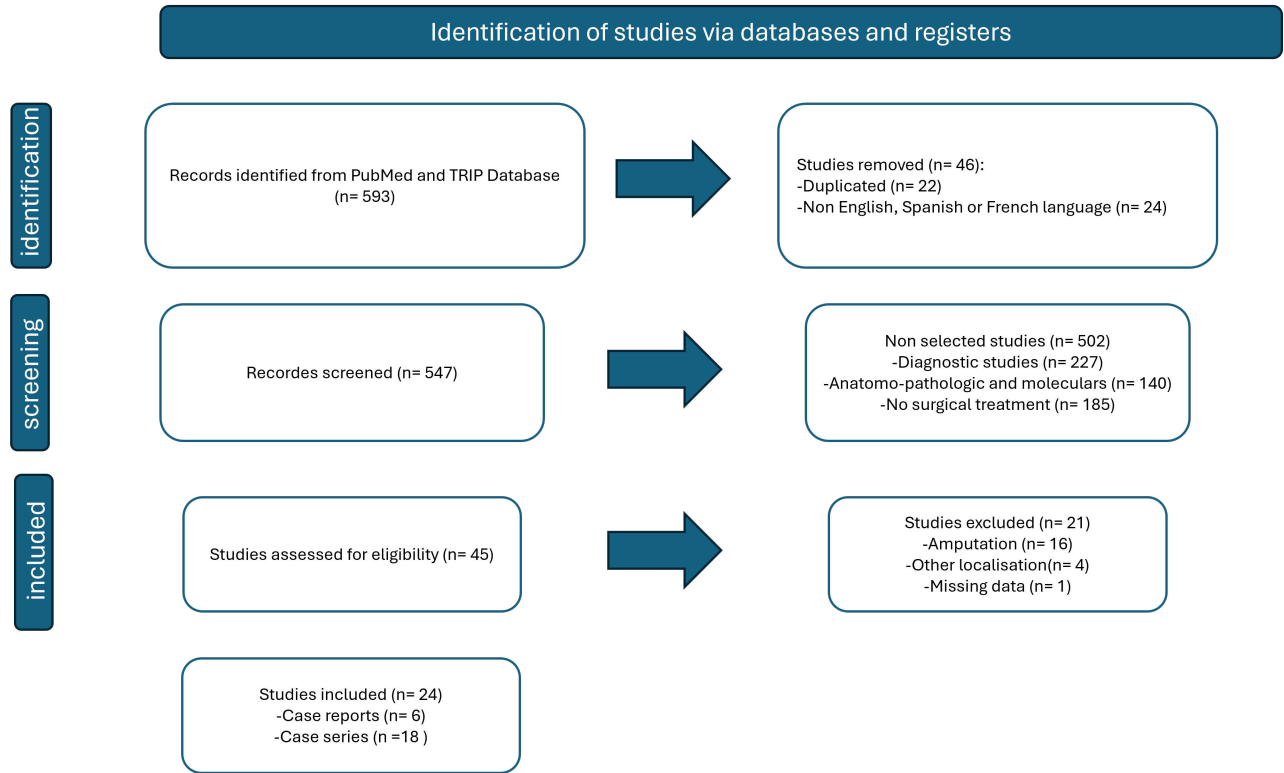


Figure 1. Flow chart.

- Study characteristics

Of the 24 studies selected, 18 were case series (13-30), and six were single case reports (31-36). All the studies were retrospective (n = 23), except for one study which was a prospective case series (36). All the studies were published between 2003 for the oldest (17) and 2023 for the most recent (20).

- Demographic characteristics

Sample sizes varied from study to study, ranging from 1 to 140 (20) participants, for a total of 373 patients, with an average age of 53.4 years (4 to 81 years). Women predominated, with 252 of the 373 patients being women, representing a sex ratio of 67%.

One study did not specify the sex of the patients (26).

- Anatomical localisation

Of the articles included for which the location was specified, 91 patients had involvement of the lower limb - including 25 cases involving the hallux when this information was available - and 164 patients had involvement of the upper limb - including 50 cases involving the thumb. However, for 118 patients, the precise anatomical location was not reported. Four studies did not mention the location of the lesion at all (15, 17, 22, 25).

- Melanoma type

Regarding the diagnostic phase, the majority of articles (16, 20, 22-24, 26, 28, 30, 31, 33-35) reported that an initial biopsy was performed. Only one article (32) mentioned an immediate biopsy-exeresis, while two studies (18, 36) mentioned the absence of a biopsy. The presence or absence of prior biopsy was not specified in nine articles (13-15, 17, 19, 21, 25, 27, 29). When the degree of local invasion was reported, the majority of melanomas were in situ (n = 65). Among the invasive forms, five cases had a Breslow index of less than 1 mm, two cases a Breslow of between 1 and 3 mm, and two cases a Breslow of more than 3 mm. Six studies did not mention the stage of the melanoma (17, 18, 20-22).

- Margins

These were not tumour resection margins in the strict sense of the term, but margins for resection of the entire nail apparatus, generally set at 5 mm in most studies (13-19, 22, 24, 34-36). However, some publications have reported wider margins of 10 mm (23, 31, 33, 35), while others have recommended narrower margins of 3 mm (20, 32). The standard Mohs micrographic surgery technique was used in two studies (25, 30), and the delayed Mohs or 'Slow Mohs' technique was also mentioned in two other publications (25, 30). Finally, one study reported the use of extemporaneous anatomopathological examination to check the margins of excision of the nail apparatus (28).

- Strategy for reconstruction

Full thickness skin graft (FTSG) was the preferred reconstruction technique in the majority of studies (13-19, 21, 23, 24, 27, 30-32), involving a total of 112 patients. Of these, ten studies (14-16, 19, 23, 24, 27, 30-32) reported that FTSG was performed immediately, at the same time as the extended excision, in 52 patients. In contrast, seven studies reported delayed reconstruction, involving 55 patients (14, 15, 17, 18, 24, 28-30, 32, 33, 36). The immediate or delayed nature of the reconstruction was not specified in four publications (13, 18, 21, 25).

Only the series by Crisan et al. reported the use of a negative pressure dressing in preparation for delayed FTSG (43). FTSG was used exclusively in 71 patients (13-15, 18, 19, 21, 23, 24, 29-32), combined with a dermal matrix in five cases ((28, 33, 36), and combined with a perionychium flap in 43 patients (16, 17, 19). One study used a delayed thin skin graft after Mohs micrographic analysis (25).

With regard to the use of dermal matrices, three articles (28, 33, 36) were concerned, involving a total of five patients, for whom the dermal matrix was placed at the same time as the resection and a second stage with the placement of a FTSG three weeks after the first stage was carried out. Only PELNAC® matrix was used, except in one study where INTEGRA® was used (33).

Regarding flaps, only Motta et al. and Lee et al. (22, 35) who used free flaps, respectively a free toe transfer in one case, and ultra-thin perforating flaps of the superficial circumflex iliac artery (SCIP) in 41 cases, whereas eight studies mentioned local flaps, six of which in association with a FTSG (13, 16-19, 30) and two exclusive Foucher flap reconstruction (26, 34). Local flaps combined with FTSG were most often perionychium advancement or palmar advancement flaps (16, 17, 19); one case report proposed a cross-finger flap (30). Finally, two studies favoured directed healing only (18, 25) and one study did not mention the surgical technique for reconstruction (35).

• Post-operative complications

The most frequently observed complication was melanoma recurrence, found in 11 studies ((15, 17-22, 24-26, 29, 30) involving a total of 67 patients. Of these, 13 required secondary amputation of the affected digit (15, 18, 19, 24-26, 29, 30). In 2 cases, recurrence was linked to histologically positive excision margins, requiring amputation (15, 29).

In a further 33 cases, the status of the margins was not specified, and the treatment options varied: 11 patients underwent amputation (18, 19, 24-26, 30), and 5 underwent revision surgery of the margins (17, 22, 25), including 3 by deferred Mohs technique (25). As regards distant recurrence, 21 cases were described (17, 19-22, 25) including:

- 2 transit metastases, one of which was treated surgically (17, 22)
- 10 lymph node involvement (17, 21)
- 11 visceral metastases, resulting in 2 deaths (17, 19, 20, 25).
- Residual nail spicules were reported in 15 patients (13, 15, 16, 18) and epidermal cysts in 13 patients (13-15, 18). Other adverse events included:
- 10 cases of hypersensitivity to cold or shock;
- 9 cases of graft hyperpigmentation (13);
- 1 case of distal interphalangeal arthritis (29);
- 1 flexor sheath hematoma (24);
- 1 case of temporary functional exclusion of the finger (14).

Six studies reported no complications (23, 27, 28, 33, 34, 36) and two did not mention this criterion (31, 35)

• Complementary treatments

Most studies did not mention complementary treatments (n=23).

Only one study (29) described complementary treatments, with an adjuvant course of Interferon alpha for one patient, in the context of the appearance of distant metastases. This same study also described a case of recurrence treated by radiotherapy, with an unspecified impact on the outcome of reconstruction, and a case of multiple recurrences of metastases in transit treated by iterative excision and directed healing. The sentinel node procedure was mentioned only in the study by Wollina et al, involving four patients, only one of whom had a micrometastasis (21). No study mentioned immunotherapy.

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- Functional and cosmetic results

Post-operative functional and cosmetic results were assessed by the examiner in six studies (18, 29, 31-33, 35), by the patient in six other studies (14-16, 22, 28, 34), and by the patient and the examiner in one study (23); six studies did not mention who the assessor was ((13, 17, 24, 25, 27, 33, 36).

Functional recovery was judged acceptable to satisfactory in eight studies, involving a total of 80 patients (13, 14, 16-18, 23, 28, 29), whereas it was considered total, with a return to normal function in seven studies (14, 18, 24, 32-35) involving 39 patients.

Regarding the cosmetic result, it was judged to be little disturbed or good in 12 articles (13, 15-18, 23, 26, 28, 29, 31, 33, 36), involving 76 patients, whereas it was judged to be excellent or equivalent to the previous state in four studies (18, 24, 34, 35), involving 42 patients with heterogeneous surgical techniques: exclusive directed healing (18), Foucher flap in the case report of one patient (34), free onycho-cutaneous flap harvested from the hallux in the case report of one patient (35), and six cases treated by FTSG and five by exclusive directed healing in the series by Neczyporenko et al. (24). The cosmetic result was judged to be poor in only two patients in the series by Goettmann et al. (18), but although directed healing was the predominant choice, the technique used for these two patients were not specified.

Only one article classified its results using validated questionnaires, that of Lee et al (22), which found an average Quick-Disabilities of the Arm, Shoulder and Hand (DASH) score of 1.3 in the 14 patients undergoing surgery on the upper limb and an average Foot Function Index (FFI) score of 3.1 in the 12 patients undergoing surgery on the lower limb.

The time to return to work was specified in two studies (29, 33), and averaged four and six weeks respectively after the last operation.

- Post-operative follow-up

Reported follow-up ranged from 3 months (34-36) to 120 months (18). The mean follow-up was 60.1 months, with a mean of 45 months.

Ref.	Type of article Number of patients Distribution Mean age (years) (range)	Localisa- tion F (Finger) T (Toe) (n)	Local ex- tension	Presence of previous biopsy Margins from Nail apparatus	Strategy of econstruction Surgical management	Side effects, Complications	Complemen- tary treatment	Results	Follow up mean (range)
Anda- Juarez et al, An Bras Derma- tol, 2016	Retrospective 15 patients (9F, 6M) 31 (4-66)	Right hand: F2(2), F4(2), F5(1) Left hand: F1 (1), F5 (3) Right foot (5): T1 (5) Left foot (1): T1	SUM in situ	5 mm Supra periosteum re- section	FTSG (14) Banner flap (1 patient)	No recurrence Inclusion cysts (4) Spicules (6) Hypersensitivity (4) Moderate chronic pain (1) Hyperpigmentation of the skin graft (9)	NA	Functional and cos- metic outcome was good in all of them	55 months (12-98)
Lazar et al, Hand- Surg Br, 2005	Retrospective 13 patients (8F, 5M) 10 patients with SUM (7F, 3M) 40 (NA)	Right hand F1(3), F3(1), F5(1) Left hand: F1 (2), F5(3)	SUM in situ	5 mm	Immediate FTSG harvested from same forearm (9) Delayed FTSG harvested from same forearm (1)	Temporary finger exclu- sion (1case) Epidermal cyst (5 cases)	NA	Sensitivity: Weber 4- 6mm (7), NA (1) Normal function (4), Slightly limited function (5), NA (1) Cosmetic outcome: Satisfied or normal (9), NA (1)	48 months (6 – 84)
Puhain- dran et al, Tech Hand Up Ex- trem Surg, 2011	Retrospective 10 patients (4F, 6 M) 6 patients with a SUM MA 52 (24-80)	NA	SUM in situ, <2cm diame- ter	2 mm to nail fold	Immediate FTSG	Positive margin (1), treated by PID Disartic- ulation Secondary surgery: Epidermal inclusion cyst (1) Nail remnant (1)	NA	Acceptable appear- ance for all patients (assessed by 2 sur- geons) Patients satisfied (6) Unrestricted use of the hand (6)	35 months (8- 72)

Flores-Terry et al, Actas Dermo-sifiliogr, 2018	Retrospective 11 patients 7 patients with SUM (4F, 3M) 5 patients (3F, 2M) treated by WLE 61 (45-81)	Right hand: F2(1) F3(1) Left hand F1(1) F2(1) Right foot: T1 (1)	SUM in situ (4) or Sum with Breslow <1 mm (1)	Previous biopsy 5 mm Supra periosteum resection	Circumferential advancement flap and Immediate FTSG	No recurrency (5) Wound infection (2) subungual spicules (1), moderate stiffness of DIP of one finger (1) hypersensitivity to cold (2), hypersensitivity to mild trauma (4)	NA	Patients were satisfied with the procedure and the results obtained (5) Satisfaction was good and the impact on quality of life was minimal (5)	39 months (12-96)
Moehrle et al, Dermatol Surg, 2003	Retrospective 62 patients with SUM (25H, 37F) 31 treated by WLE (11 H, 20F) MA 61	F1,2,3,4,5(20) T1,2,3,4,5 (11)	SUM in situ Invasive SUM Breslow < 1mm (6) Breslow 1 to 2mm (8) Breslow 2 to 4mm (6) Breslow > 4mm (4) NA: (7)	5 mm WLE with safety margin without bone resection (3) WLE with safety margin with resection of the distal part of the distal phalanx (28)	FTSG with pulpal advancement flap Single stage (1) Several stages (30) Unspecified reconstruction after definitive three-dimensional histology	Recurrences (20 patients) Local recurrence (2) In transit recurrence (1) Lymph node metastasis (7) Distant metastasis (1)	NA	Function and cosmesis of the involved finger or toe « preserved »	54 months (NA)

Goettmann et al, J Eur Acad Dermatol Venereol, 2018	Retrospective 63 patients (44F, 19M) 58 treated by WLE 51 (NA)	F1 (24) F2,3,4,5 (23) T1 (10) T3(1)	All SUM, if pulp not involved	No previous biopsy WLE (12) Partial excision of the appliance removing the lesion, and the nearby paronychium (47)	Healing by secondary intention (52) FTSG (3 patients) Flap (1)	Local recurrences at 24 and 32 months treated by amputation (2) Spicules (7) Epidermal cysts (2)	NA	No functional discomfort (20) Moderate discomfort (14) Aesthetic discomfort was judged to be absent (29) Moderate aesthetic discomfort (8) Severe aesthetic discomfort (2)	120 months (NA)
Chow et al, J Plast Reconstr Surg, 2013	Case report 1 M with SUM in situ 41	Right T1 (1)	SUM in situ	Biopsy 10 mm WLE with a layer of bone	Immediate FTSG (harvested from the groin)	NA	NA	Acceptable cosmetic result (assessed by surgeon)	5 months
Duarte et al, Dermatol, 2010	Case report 1 F with SUM in situ 61	Right F1 (1)	SUM in situ	Excisional biopsy 3 weeks later 3 mm margin WLE	FTSG taken from the arm	No local recurrence or metastasis	NA	Thumb function completely preserved	12 months
High et al, Arch Dermatol, 2004	Retrospective 7 patients (5F, 2M) with SUM in situ 4 patients treated by WLE MA 56 (NA)	Right hand (1): F2 Left hand (2): F2(1), F5(1) Right foot (1): T1(1)	SUM in situ	Previous biopsy MOHS surgery: 1 stage (3) 2 stages (1)	FTSG taken from the arm (3) cross finger flap (1)	Recurrence: (1) treated by revisional amputation	NA	NA	24 months (10-29)

Sinno et al, J Plast Surg Hand Surg, 2015	Retrospective 35 patients with melanoma of the hand (24F, 11M) 18 patients with SUM 10 patients with SUM treated by WLE	F1 (8) F2 (12) F3(3) F5(3)	Melanomas in situ (7) Invasive Melanoma T2(1 patients) B=2.5mm Invasive Melanoma T3 (2); B=3.00mm and B=3.08mm	5 mm	FTSG (3) Paronychial advancement flap + FTSG (3) Paronychial advancement flap + forearm flap + FTSG (1) Paronychial advancement flap + FTSG Volar Flap FTSG (1) FTSG Volar and dorsal advancement flaps (1) FTSG Local advancement flap (1)	Revisional amputation (3) Unknow (1) Deceased (1)	NA	NA	47 months (7–74)
Smock et al, J Plast Re-constr Aesthet Surg, 2010	Case report 1 M 44	Right F1 (1)	Ulcerated SUM Bres-low of 1.2 mm	Previous Biopsy 10 mm, including the periosteum	Immediate reconstruction by dermal matrix (INTEGRA) STSG 3 weeks later	None	NA	Fully functional thumb and a good cosmetic result Went back to job at 4 weeks	24 months
Bjedov et al, Acta Dermato Venereol Croat, 2019	Case report (1) F, 31	Left F1 (1)	SUM in situ	Several nail matrix biopsies 5 mm, with periosteum Mohs analysis	Pedicled innervated Fascio cutaneous Foucher's flap Donor site was covered with a FTSG taken from the volar side of the elbow.	None	NA	The hand was fully functional, and the patient was very satisfied with the appearance of the thumb Full sensory cortical reorientation	3 months
Oh et al, J Am Acad Dermatol, 2023	Retrospective 140 patients with SUM 107 with conservative treatment (57 F, 50 H) Mean age: 56	F1,2,3,4,5 (71) T1,2,3,4,5 (36)	If no bone invasion (MRI + biopsy)	Biopsy and MRI at least 3 to 4 mm, with periosteum	NA	Recurrency (23 patients): Local recurrence (15) Distant recurrences (8)	NA	NA	45 months (14- 76)

Motta et al, Arch Dermatol, 2007	Case report 12 years old, F	Right F1 (1)	SUM in situ	Biopsy WLE with Mohs Micrographic analysis 5-10mm (lateral) 5 mm (proximal and distal edges)	Two stages Second stage (1week later) microvascular composite on- ycho-cutaneous free flap from the right first toe	NA	NA	Normal nail growth and full mobility of the interphalangeal thumb joint were present	3 months
Wollina et al, Dermatol Ther, 2019	Retrospective Serie of 12 patients with SUM) 6 patients with conservative treatment (2F, 4M) 76 (NA)	Right foot T1(2) T3 (1) Left foot: T1 (3)	SUM with Breslow between 1.6 mm to 4.8 mm	Wide excision (4) Excision with delayed Mohs surgery (2)	Full thickness skin trans- plantation. One patient refused, second intention healing	Local relapse (2) Later metastasis () Satellites only (1 patient, B=2.55) Liver, pancreas, spleen, lymph nodes, stomach, adrenal glands, greater omentum, CNS (1, with Breslow =4.8mm) In transit, lymph node regional, pericardium (1, with Breslow=3.20)	Sentinel Lymph node (4), with micro-invasion (1) Polychemotherapy for later me- tastasis (1) Transit metastases treated by er- bium YAG-laser as a palliative measure (1) interferon-alfa therapy for 9 years after sur- gery satellites metastasis (1) Adjuvant radio- therapy (1)	NA	104 months (17 -208)
Crisan et al, Acad Dermatol Venereol, 2017	Retrospective Serie of 7 patients (3F, 4H) 64 (NA)	F1 (3) F4 (3) T1 (1)	SUM in situ pT1a (1) pT1b (1)	WLE (7) NA	First stage: vacuum-assisted closure Second stage: FTSG (5)	Second stage amputa- tion (2 patients) for: -DIP joint arthritis (1) -Positive margin (1)	NA	At 6 weeks, the 5 pa- tients grafted could resume normal ac- tivity Good cosmetic and functional	12 months (NA)
Lee et al, Plast Re-constr Surg, 2017	Prospective 41 patients with conservative	Fingers: 25 Toes: 16	SUM with Breslow thickness of ≤ 2 mm on	Preoperative biopsy 5-mm with perios- teum excise (10 mm margin if in- vasive lesion)	Immediate reconstruction by SCIP flap with a final thick- ness ranging from 1.5 to 4 mm after defatting	Necrosis of the flap (1) (arterial insufficiency) Venous congestion (3) with partial necrosis of the flap	NA	Average healing time: 15 days Questionnaire car- ried out on 26	31 months (NA)

	treatment (21M, 20F) 51.1 (NA)		preoperative biopsy		(Scouted with Doppler) End to end anastomosis with digital artery and dorsal vein Donor site primary closing	Seroma of the donor site (1) Recurrences: -local recurrence (1) -metastasis in transit (1) Second surgical stage until degreasing (12)		patients: WLE in the upper limb (14): The mean Quick-DASH score was 1.3 (range 0 to 6.8). WLE in the lower limb (12): FFI survey for foot lesions, mean score was 3.1 (range 0 to 8.0)	
Hayashi et al, Dermatol Surg, 2012	Case report (1M), 52	Left F3	SUM in situ	No biopsy 5 mm with excision of periosteum	Immediate reconstruction with artificial dermis (PELNAC) Second stage at 4 weeks with FTSG	No recurrency No metastasis	NA	Good cosmetic results	3 months
Sureda et al, Br J Dermatol, 2011	Retrospective Serie of 7 patients (5F, 2M) MA 58 y	F1(2), F2(2), F4(1) T1 (2)	SUM in situ (5) or minimally invasive SUM (2) (Breslow 0.2 and 0.15)	Biopsy systematically 5-10 mm Deep margin was bone contact	Immediate FTSG taken from the internal aspect of an arm	No recurrence	NA	Interrogation of patient and observer: High level of satisfaction, a good functional and quite good cosmetic result.	45 months (24-84)
Nec- zyporen ko et al, J Eur Acad Dermatol Venerol, 2014	Retrospective Serie of 11 patients (8 F, 3 M) 48 (NA)	Right hand: F1(3), F2(1), F5(1) Left hand: F1(1) F2(1) T1(3), T2(1)	Melanoma in situ	Biopsy systematically (tangential or punch) 6 mm	Immediate FTSG (6) Secondary intention and delayed FTSG (5)	Tendon sheath haematoma (1) Lymphangitis post (1) Recurrence treated by secondary amputation and sentinel node (2) (7- and 11-years post op)	NA	Healing by secondary intention and grafting were fully satisfactory, cosmetically and functionally	65 months (5-167)

Terushkin et al, Dermatol Surg, 2016	Retrospective Serie of 40 patients (21 F,19M) 63 (NA)	NA	WLE in cases of extensive SUM (>40% of the bed)	Excisional biopsy with Mohs micrograph, Supra Periosteum dissection	Second intention FTSG STSG	Recurrences (5) Second operation with complete excision of the matrix (2) Amputation (2) Death due to metastasis (1)	NA	NA	76 months (2-276)
Rayatt et al, Plast Reconstr Aesthet Surg, 2007	Retrospective Serie of 4 patients 56 (NA)	F1 (4)	SUM without deep margin clinically involved Breslow 0.9mm to 4mm	All had initial biopsies to confirm the diagnosis 10 mm including the periosteum	Immediate: -Foucher flap (1) -Flag flap (2) Delayed reconstruction (flag flap) (1)	Recurrence at 36 months treated by amputation (1)	NA	Usefully maintain function.	72 months (-117)
Imakado et al, J Dermatol, 2008	Retrospective Serie of 2 patients (1M, 1F) 50	Left F3 (1) Right F5(1)	SUM in situ	All the nail apparatus with nail folds	Immediate FTSG	No recurrence	NA	NA	27 months (6 -48)
Liu et al, Medicina, 2020	Retrospective Serie of 4 patients with malignant tumour of nail apparatus 3 patients with SUM suspicion (1F, 2M) MA 55 y	Left T1 (1) Right T1 (2)	SUM in situ (2) hyperpigmentation in basal layer of epidermis (1)	Previous biopsy (2) WLE Adequate margin control confirmed by intraoperative frozen sections	Two stages reconstruction Immediate acellular dermal matrix (PELNAC) At 10 days, the acellular dermal matrix was removed and re-dressed in a new one at the outpatient clinic FTSG at 3 weeks	No Recurrence	NA	These patients experienced minimal change in body contour, mild but acceptable functional deficit, and satisfying aesthetic results.	9 months (5-13)

Table 1 summarizes the characteristics of the included studies

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<i>Retrospective monocentric study of a series of patient</i>	310
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Population characteristics	312
A total of ten patients with an average age of 62.4 ± 10.8 years (48 to 80) were included.	313
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Seven were retired and three were working. There were no active smokers in our study, and the main comorbidities were arterial hypertension in three patients, type 2 diabetes in one, and obstructive lung disease in one patient who had stopped smoking. The mean follow-up period was 18 ± 7.1 months (7 to 29). Six cases involved involvement of the upper limb, including four of the thumbs and two of the long fingers, and four cases involved involvement of the lower limb, including three of the halluces and one of the second toe. There were seven cases of in situ melanoma and three cases of invasive melanoma, two of which were identified during the preoperative biopsy. The depth of the Breslow index reported after the operation was 0.9 ± 0.21 mm on average (0.7 to 1.2), for the invasive melanomas. Two cases involved margins affected after extended excision of the nail apparatus, treated respectively by amputation of the digit concerned and by re-doing the margins during the second stage of reconstruction, without additional treatment.	315
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Per-operative data	329
A total of ten patients with an average age of 62.4 ± 10.8 years (48 to 80) were included. Seven were retired and three were working. There were no active smokers in our study, and the main comorbidities were arterial hypertension in three patients, type 2 diabetes in one, and obstructive lung disease in one patient who had stopped smoking. The mean follow-up period was 18 ± 7.1 months (7 to 29). Six cases involved involvement of the upper limb, including four of the thumbs and two of the long fingers, and four cases involved involvement of the lower limb, including three of the halluces and one of the second toe. There were seven cases of in situ melanoma and three cases of invasive melanoma, two of which were identified during the preoperative biopsy. The depth of the Breslow index reported after the operation was 0.9 ± 0.21 mm on average (0.7 to 1.2), for the invasive melanomas. Two cases involved margins affected after extended excision of the nail apparatus, treated respectively by amputation of the digit concerned and by re-doing the margins during the second stage of reconstruction, without additional treatment.	330
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Post-operative data	345
From a carcinologic point of view, two patients had positive margins after WLE, one of whom was successfully treated by re-doing the margins during the second stage of reconstruction, and one of whom had the digit concerned amputated in the month following WLE and died because of metastatic dissemination of the disease.	346
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No major post-operative complications were reported, and no emergency surgery was required. The main complications were late complications, such as hypoesthesia with difficulty in using the forceps in one case, but above all hyperesthesia to contact (two cases) and to temperature variations, with acro-vascular phenomena in patients with upper limb disease. One patient (case 10) presented with a nail spicule at the surgical site, which interfered with footwear and was taken back for the excision of this remnant.	350
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Hyperpigmentation of the graft was observed in only one case, which had undergone a two-stage reconstruction with a dermal matrix followed by a total skin graft.

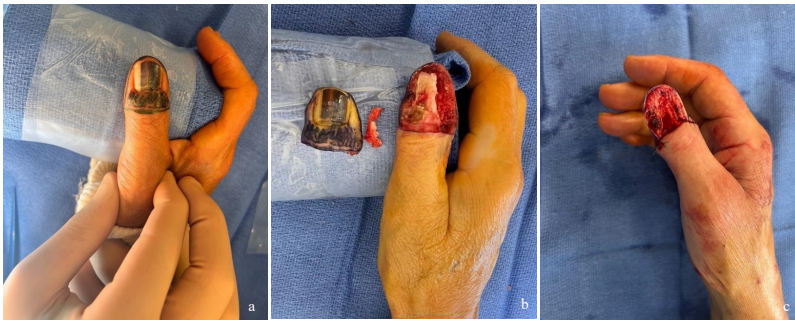


Figure 2. Photographs of the dorsal surface of thumbs with SUM, treated with WLE, from our series. a. Intraoperative view before WLE. b, c. Intraoperative views after WLE, illustrating the extent of the soft tissue defect.



Figure 3. Photographs of the dorsal aspect of thumbs in patients with SUM, treated with WLE and reconstructed using dermal matrices. a. Intraoperative view after WLE and placement of a fixed dermal matrix (Novosorb BTM). b. Intraoperative view after WLE and placement of a fixed dermal matrix (INTEGRA).



Figure 4. Photographs of the dorsal surface of the right thumb and index finger treated by WLE in our series. a. Photographs of the right thumb reconstructed with dermal matrix and FTSG, with secondary hyperpigmentation of the graft. b. Photographs of the right index finger reconstructed with a distal pedicle adipofascial flap.



Figure 5. Photographs of the dorsal aspect of the left foot in a patient with SUM of the hallux treated with WLE and reconstructed with an intermetatarsal pedicled flap from the first space.

a. Preoperative: flap design based on the perforator of the first dorsal metacarpal artery in the first space.

b. Intraoperative views after WLE, illustrating the extent of soft tissue defect.

c. Aspect at 2 days post-operatively.



Figure 6 Photographs of the dorsal aspect of thumbs in SUM patients treated with WLE and reconstructed with dermal matrices and FTSG in our series. a. Dorsal view. b. Radial edge view. c. Ulnar edge view.

Regarding the objective of functional and cosmetic recovery, of the 9 patients who underwent functional surgery, 7 completed the questionnaire after an average of 19.2 months. There were 4 cases with lesions on the fingers and 3 on the toes. The mean Quick-DASH score was 25.5 ± 16.4 (2.3 to 41) (score ranging from 0, no handicap, to 100, maximum handicap) and concerned two patients reconstructed by matrix and total skin graft,

with scores of 18 and 41 respectively, one patient reconstructed by adipo-fascial flap with distal pedicle, with a score of 2.3 and one patient reconstructed by FTSG alone, with a score of 41. The Modified Mayo Wrist Score (score ranging from 0, maximum disability, to 100, no disability) averaged 78.5 ± 4.8 (75 to 85), respectively 75 and 85 for the two cases of reconstruction by dermal matrix and FTSG, 75 for the case of reconstruction by distal pedicle adipofascial flap and 80 for the case of reconstruction by FTSG alone.

Finally, for cases with foot lesions, the mean AOFAS score was 86 ± 4.1 (80 to 90) (score ranging from 0, maximum disability, to 90, no disability). Details of the results are given in **Table 2**.

Table 2. Clinical characteristics and functional results of our 10 patients reconstructed after WLE

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Case	Age	Work	Dominant member	Sex	History	Location	Biopsy before WLE	Histopathology after WLE	Stage 1 surgery (Margins) (Duration)	Stage 2 surgery	Operation interval	Side effects / complications	Score (%)	Cumulated Length of time off work	Follow-up Period
1	73	Retired	Right	M	HTN	Right Fg1	Invasive SUM	Invasive SUM Breslow = 1,2mm	WLE (NA)	Amputation trans P1 (17 min)	45 days	Brain metastasis, death	NA	None	24 months
2	68	Retired	Right	F	None	Right Fg1	SUM in situ	SUM in situ	WLE + Dermal Matrix (29 min)	recovery of operating margins + FTSG (33 min)	45 days	Hyposensitivity of the pinch, dropping objects Cold Hypersensitivity	MWS: 85 Quick DASH: 41	None	29 months
3	48	Notary	Right	F	None	Left Fg4	SUM in situ	SUM in situ	WLE (5mm) (25 min)	FTSG (24 min)	15 days	Cold and Warm Hypersensitivity Tactical hypersensitivity of dorsal fingertip	MWS: 80 Quick DASH: 41	9 Weeks	18 months
4	66	Retired	Right	F	None	Right Fg1	SUM in situ	Invasive SUM Breslow = 0.7mm	WLE (6mm) + Dermal Matrix (29 min)	FTSG (33 min)	21 days	None	MWS :75 Quick DASH: 18	None	19 months

5	54	Commer- cial	Right	M	None	Right Fg1	SUM in situ	SUM in situ	WLE + Dermal Matrix (35 min)	FTSG (28 min)	21 days	None	NA	NA	13 months
6	80	Retired	Right	M	HTN, COPD	Right Fg2	SUM in situ	SUM in situ	WLE + Fascio-adi- pous flap (41 min)	None	None	Cold hyper- sensitivity Tactical hy- persensitiv- ity of dorsal fingertip	MWS :75 Quick Dash: 2.3	None	8 months
7	74	Retired	NA	F	HTN	Left T1	SUM in situ	SUM in situ	WLE + Inter meta- tarsal flap (68 min)	None	None	None	AOFAS: 90	None	25 months
8	49	Commer- cial	NA	F	Dia- betic	Right T1	Inva- sive SUM	Invasive SUM Bres- low=0.8mm	WLE + Inter meta- tarsal flap (55 min)	None	None	None	AOFAS: 80	6 Weeks	24 months
9	60	Retired	NA	M	None	Right T1	SUM in situ	SUM in situ	WLE + Dermal Matrix + STSG (39 min)	None	None	None	AOFAS: 90	None (stopped for per- sonal reasons)	13 months
10	52	Nurse	NA	F	None	Left T2	SUM in situ	SUM in situ	WLE+ Pulp ad- vancement flap	None	None	Nail rem- nant	AOFAS: 87	1 day	7 months

4. Discussion

The management of subungual melanoma has evolved significantly since it was first described in the nineteenth century ((37). This topographical form seems to preferentially affect women, as shown by our review (67% of the 24 articles included were female), in line with the data of Neczyporenko et al (24).

Regarding the age of onset, the fifth decade is the most frequently reported, with a few exceptions such as the series by Lazar et al. (14), where the mean age was 40. Preoperative biopsy is not usually recommended for pigmented skin lesions, in favor of excisional biopsy (38). However, in certain functional or aesthetically sensitive areas, a biopsy may be justified as a first-line procedure. In our review, several studies did not specify the performance of a biopsy and its modality, or mentioned the absence of one, which exposes the risk of unnecessary mutilating surgery, even in the presence of effective reconstruction techniques. EAU is now preferred to amputation in cases of in situ or minimally invasive melanoma, although there is no agreed Breslow threshold (39, 40). Most articles support this strategy, with a recurrence rate comparable to that of amputation (14, 17, 26, 41, 42). Although some studies report more local recurrences after WLE, often after the operation, it should be remembered that this technique is aimed at less aggressive tumors, without metastatic disease. Furthermore, anatomopathological control may be incomplete, as pointed out by Kimyai-Asaidi et al. (43). This also explains why sentinel lymph nodes are rarely used in these cases. Conversely, amputations are reserved for more advanced forms, with a higher metastatic potential.

There is no clear consensus regarding immediate versus delayed reconstruction. Our literature review revealed a notable rate of local recurrence: 67 out of 373 patients (approximately 18%) experienced recurrence, most often requiring secondary amputation. Reported cases of amputation following histological analysis of the resection specimen—including two in our series and two in the literature—further support the rationale for delayed reconstruction, particularly in cases of invasive melanoma.

Two techniques have been proposed for margin assessment: intraoperative frozen section analysis, which is limited by the absence of specific immunostains (such as MART-1, HMB-45), and the Mohs micrographic surgery technique, either conventional or staged. While Mohs is not recommended as a standard treatment for melanoma, it is employed in certain specific cases, particularly for lentigo maligna (Dubreuilh's melanoma) (18, 57-59). It allows more precise histological control, but its accessibility remains limited and its efficacy in this context is still debated. Most articles support this strategy, with a recurrence rate comparable to that of amputation (28, 31, 40, 54, 55). Although some studies report more local recurrences after WLE, often after the operation, it should be remembered that this technique is aimed at less aggressive tumors without metastatic disease. Furthermore, anatomopathological control may be incomplete, as pointed out by Kimyai-Asaidi et al (56). This also explains why sentinel lymph nodes are rarely used in these cases. Conversely, amputations are reserved for more advanced forms, with a higher metastatic potential.

Reconstruction approaches vary total skin grafts, dermal matrices, pedicled or free flaps. The choice depends on the location, the functional importance of the finger or toe, the need for mechanical strength or, on the contrary, aesthetic requirements. Free flaps or flaps with a temporary pedicle (flag flap type) may be too invasive for certain indications, whereas a graft combined with a dermal matrix is often a good compromise, especially for distal injuries with poor function. The inner arm is often used as a donor site, due to

its hairless and discreet appearance. Dermal matrices provide post-operative comfort (less hypersensitivity) and allow coverage of ex-posed bone, enabling WLE with sub-periosteal resection or removal of the dorsal cortex of the last phalanx, although they require additional operating time. These approaches remain eligible for outpatient surgery under local anesthetic.

In our review, most of the reconstruction techniques described were based on skin grafting, alone or in association with a matrix or local flap, which could be explained by the low logistical and organizational constraints of this procedure, the quality of the results it provides, its simplicity of execution and its independence in relation to the size of the recipient site. Although a single surgical procedure is the most ergonomic option, our review found a similar number of one-stage and two-stage procedures. The latter, sometimes due to the time required to incorporate the matrix, could be dispensed with the advent of single-layer matrices. As for the functional and cosmetic results mentioned in our review, they were often judged as “good”, “acceptable” or “satisfactory”, which unfortunately made interpretation difficult and subjective. Objective results, at best reported by the patient using validated scores, would enable an effective comparison of the different techniques for a given patient profile.

In our experience, reconstruction should be adapted as far as possible to the patient's profile. However, for damage to the upper limb, the combination of a dermal matrix and a total skin graft seems to us to be the most suitable technique, due to the quality of the functional and cosmetic result. Indeed, the advantages of skin grafts, which are sensitive and dyschromic, contrast with the rest of the dorsal skin of the digit, combined with those of skin thickness restored by matrices, such as reducing the risk of hypersensitivity. The safety, simplicity and speed of the procedure mean that we can offer it as first-line treatment for most of our patients. For lower limb injuries, pedicled flaps, such as the intermetatarsal flap, are effective reconstructions. Sensitivity and aesthetics in this area are often secondary to the need for a final toe phalanx with maximum protection against hypersensitivity and pain, which is the case with thick skin coverings such as flaps. One of the disadvantages of this technique is the presence of a dorsal scar along the length of the digit and the commissural space removed, which is why we propose reconstruction by skin graft with dermal matrix as an alternative option.

Neoadjuvant immunotherapy, already used for resectable stage III melanoma, could represent a turning point for localized forms such as SUM (44). In the long term, it could make it possible to avoid certain amputations in favor of more conservative surgery such as WLE. However, these therapeutic options have not been widely studied, reflecting the persistent compartmentalization between medical and surgical disciplines.

The main limitations of our review are related to the lack of standardized functional evaluation of reconstructions, the heterogeneity of the techniques used, and the absence of precise data on histological stage. Our case series, although limited, is consistent with these observations. Prospective, multicenter studies with validated functional scores are needed to better define indications and optimize results.

5. Conclusion

The management of subungual melanoma is tending more and more towards WLE rather than amputation, particularly in situ forms or those with a low Breslow index. Reconstructive techniques, such as total skin grafts or the use of dermal matrices, provide satisfactory functional and aesthetic results. However, objective assessments of these results remain limited, and adjuvant treatments such as radiotherapy or immunotherapy

are rarely mentioned. Better standardization of practices and prospective studies are needed to refine the evaluation of long-term results.

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Abbreviations

The following abbreviations are used in this manuscript:

SUM	Subungueal melanoma
WLE	Wide local excision (of nail apparatus)
F	Finger
T	Toe
FTSG	Full thickness skin graft
STSG	Split thickness skin graft
NA	Non available
COPD	Chronic obstructive pulmonary disease
Score Quick DASH	score Quick Disabilities of the arm, shoulder and hand, (score ranges from 0, no obstacles to 100, maximum obstacles)
MMWS	score ranging from 0, maximum disability, to 100, no disability
Score AO-FAS	the American Orthopedic Foot and Ankle Score (score ranging from 0, maximum disability, to 90, no disability)

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