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ORIGINAL ARTICLE

Scalp reconstruction after oncologic resection: A retrospective comparative study of acellular dermal matrices and local flap

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Background

Scalp reconstruction is a complex challenge due to the limited tissue mobility, rich vascularization, and functional importance of the region.[1] Wide surgical excision for skin tumors, particularly basal cell carcinoma (BCC) and squamous cell carcinoma (SCC), often produces defects that cannot be closed primarily, requiring advanced reconstructive strategies.[2] Advanced reconstructive techniques are therefore essential to restore form and function while minimizing complications (Fig 1).

Traditional options include skin grafts, local and regional flaps, and free flaps.[3] Local flaps generally provide reliable vascularization, robust coverage, and lower risks of infection or cranial vault exposure,[4] but may involve donor site morbidity, prolonged operative time, and are sometimes limited by previous surgery, radiotherapy, or extensive tumor excision.[5,6]

Acellular dermal matrices (ADM) have emerged as an alternative for complex wound management, acting as biological scaffolds that promote neovascularization and dermal remodeling.[7] They offer advantages such as immediate availability, shorter initial operative times, and satisfactory aesthetic outcomes,[8] and may be particularly useful in elderly or medically fragile patients, or when donor site availability is limited. However, integration time, infection risk, and mechanical stability remain concerns.[9,10]

We hypothesized that ADM, while associated with slower healing, may represent a viable alternative for frail patients or those with limited donor tissue, by reducing operative complexity

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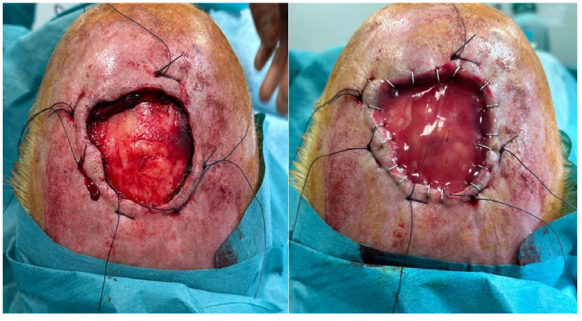

Fig. 1. Intraoperative picture of SCC wide local excision: defect after tumor excision (left), and first-stage reconstruction with ADM Integra®.

and preserving reconstructive options. A further aim was to quantify the treatment burden—defined as the number of procedures, cumulative operative time, and follow-up requirements—an aspect rarely reported in previous scalp reconstruction studies.

This retrospective case-control study aims to compare the outcomes of ADM versus local flaps for scalp reconstruction following tumor excision. Rather than positioning the 2 approaches as universally interchangeable, the present study explores how different reconstructive strategies may provide context-specific advantages depending on patient characteristics, defect features, and perioperative risk profiles. Identifying clinical indicators that support the choice of either technique is crucial to guide surgical decision-making in scalp oncology.

By evaluating healing time, complication rates, functional recovery, and patient satisfaction, this study investigates whether ADM can serve as a viable alternative to flap-based reconstruction, particularly in patients where flap options are limited or less desirable. To date, few studies have compared these 2 approaches while simultaneously accounting for patient-related and defect-specific factors, and none have systematically reported the "treatment burden" in terms of number of procedures, cumulative operative time, and overall healing trajectory.

Patients and methods

Study design

This study is a retrospective case-control analysis comparing the outcomes of acellular dermal matrices (ADM) and local flaps in scalp reconstruction following oncologic resection. The study followed the STROBE guidelines. The study included patients treated at Circolo Hospital and Macchi Foundation (Varese, Italy) between January 2020 and December 2023. The primary objective was to evaluate functional and aesthetic outcomes, complication rates, and surgical feasibility in both groups. In addition, resource utilization parameters such as number of procedures, cumulative operative time, and length of hospital stay were systematically collected in order to quantify the overall treatment burden associated with each reconstructive strategy.

Patient selection

Patients were identified from institutional surgical records and selected based on specific inclusion and exclusion criteria. Eligible patients had a histologically confirmed diagnosis of a scalp malignancy, such as basal cell carcinoma (BCC), squamous cell carcinoma (SCC), dermatofibrosarcoma protuberans (DFSP), or melanoma in situ. One patient initially diagnosed with melanoma in situ was excluded from analysis due to insufficient indication for deep excision

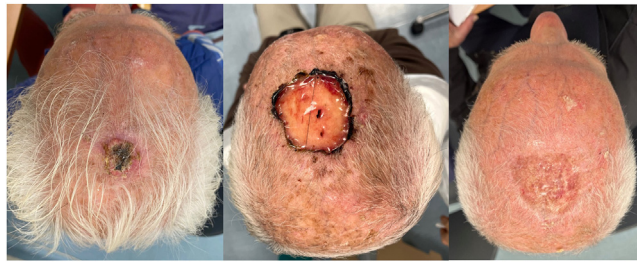

Fig. 2. Preoperative report of a patient with scalp SCC (left); ADM integration documented 21 days after first-stage surgery (center); healed result after second-stage skin graft surgery (right).

beyond the galea, in order to maintain consistency with the study's surgical criteria. Additionally, they required wide local excision resulting in a defect ≥3 cm in diameter, which could not be closed primarily, and underwent reconstruction using either ADM or a local flap. Defect size was prospectively documented in the operative reports as length and width (cm), from which surface area (cm^2) was calculated; this measurement was available for all patients. Patients were included only if they had a minimum follow-up of 12 months with complete medical records and photographic documentation. Complete wound healing was defined a priori as full epithelialization of the resection defect and, when applicable, of the donor site, or complete closure of surgical incisions, without drainage or crusting. Healing was assessed clinically by the operating team at scheduled follow-up visits and confirmed by photographic documentation.

Exclusion criteria included previous radiation therapy to the scalp, active infection at the surgical site, recurrent tumors requiring re-reconstruction, or severe comorbidities that could significantly impact wound healing, such as poorly controlled diabetes or immunosuppression. Patients lost to follow-up were also excluded. No patients received adjuvant radiotherapy after reconstruction.

Surgical techniques

In both groups, tumor resection was performed following the standard wide local excision approach, ensuring tumor-free margins. In some cases, intraoperative frozen section analysis was used to assess the resection margins. In all cases, resection was extended for oncologic radicality down to and including the deep periosteal plane.

The ADM group underwent a 2-stage reconstructive approach. After tumor excision, the outer table of the skull was drilled to create a bleeding wound bed, which was necessary for the integration of the matrix. Drilling was standardized and performed in all ADM cases using a round burr to a depth of approximately 1–2 mm, in a grid-like pattern spaced 5–10 mm apart, to ensure uniform neovascularization and consistent matrix integration across patients. No patients in the flap group required drilling. An acellular dermal matrix (Integra®) was placed over the defect and secured with sutures or staples. A silicone layer was left in place to facilitate neovascularization and dermal regeneration. After an integration period of 3 to 4 weeks, the silicone layer was removed, and a split-thickness skin graft (STSG) was applied to achieve full epithelialization.

In the majority of cases, a split-thickness skin graft (STSG) harvested from the thigh was used ($n = 13$), while in selected patients with poor graft recipient beds or aesthetic concerns, full-thickness skin grafts (FTSG) from the arm, groin, or supraclavicular region were applied ($n = 8$). The choice of graft type was guided by tissue availability and aesthetic considerations and was consistently documented in the operative records (Figs. 2 and 3).

In the flap group, reconstruction was performed using local advancement, rotation, or transposition flaps, selected based on defect size, location, and available surrounding tissue. Drilling

Fig. 3. Treatment of a patient with scalp DFSP: preoperative finding (above left); intraoperative wide local excision (above right); reconstruction with loco-regional pedicled advancement flap (below left); final result 3 weeks after surgery (below right).

of the outer skull table was not required for oncologic radicality in any of the patients in the control group. In cases of larger defects, multiple flaps, loco-regional flaps, or free flaps were used to optimize closure. All flaps were designed to achieve tension-free closure with adequate vascular supply, thereby minimizing the risk of ischemia and necrosis.

All patients received perioperative antibiotic prophylaxis consisting of intravenous cefazolin 2 g administered 30 minutes before incision. In patients with known beta-lactam allergy, clindamycin 600 mg was used. No postoperative antibiotic regimens were continued beyond the first 24 hours unless infection was suspected clinically.

Outcome measures

The study assessed primary and secondary outcomes to compare the effectiveness of the 2 reconstructive techniques. The primary outcomes included wound healing time, defined as the number of days to complete epithelialization of the resection defect and, when applicable, of the donor site, or complete closure of surgical incisions without drainage or crusting. Healing was confirmed clinically during follow-up visits and documented with photographs. Complication rates were also evaluated, including infection (clinical diagnosis requiring antibiotics and/or debridement), necrosis (nonviable tissue requiring debridement), and dehiscence (wound edge separation >5 mm). Aesthetic outcomes were assessed using the Vancouver Scar Scale (VSS) and Patient Satisfaction Score (PSS, 1–5 scale).[11,12]

Secondary outcomes included operative time (minutes), length of hospital stay, and the need for additional procedures such as revision surgery or secondary grafting. To capture the overall treatment burden, the number of procedures per patient, cumulative operative time (for both stages in ADM cases), and number of outpatient visits until complete healing were also recorded. A cost analysis was performed, considering surgical material costs, length of hospitalization, and the need for secondary interventions.

Table 1
Demographic analysis.

		ADM group (Cases)	Flap group (Controls)	P value
Total number		21	24	N.A.
Age *(mean)*		77,29	78	0.848
Sex (n; %)	*Male*	19 (90,48%)	20 (83,33%)	0.67
	Female	2 (9,52%)	4 (16,67 %)	0.482
Smoking habit (n; %)	*Active smokers*	3 (14,29%)	5 (20,83%)	0.567
	Non smokers	18 (85,71%)	19 (79,17%)	0.70
Diabetes (n; %)		5 (23,81%)	6 (25%)	0.926
Hypercholesterolemia (n; %)		8 (38,1%)	12 (50%)	0.423
Hematologic disorders (n; %)		6 (28,57%)	6 (25%)	0.787

Legend: N.A., not applicable.

Statistical analysis

All collected data were analyzed using SPSS v.30. Continuous variables, such as wound healing time and operative duration, were compared using t-tests or Mann-Whitney U tests, while categorical variables, such as complication rates and the need for revision surgery, were analyzed using chi-square or Fisher's exact tests. A p-value < 0.05 was considered statistically significant.

Results

Patient demographics and clinical characteristics

A total of 45 patients were included in the study, with 21 patients in the ADM group and 24 in the flap group. The mean age of the cohort was 78.5 years (range 29–97 years), with 86.7% male and 13.3% female. The 2 groups were comparable, with no significant differences in age, sex distribution, comorbidities (such as diabetes or smoking history), or tumor type ($P > 0.05$), ensuring homogeneity of baseline characteristics (Table 1).

The most common malignancy was squamous cell carcinoma ($n = 34$; 75.5%), followed by basal cell carcinoma ($n = 9$; 20%), dermatofibrosarcoma protuberans ($n = 1$; 2%), and melanoma in situ ($n = 1$; 2%) (Table 2). Defect size was systematically recorded in the operative reports, and the mean defect area after tumor excision was 78.75 cm^2, with no significant differences between groups ($p = 0.950$).

Given the advanced mean age of the cohort, this study reflects a real-world population frequently affected by scalp skin cancers and highlights the clinical relevance of exploring less invasive reconstructive strategies such as ADM.

Wound healing and surgical outcomes

The analysis of wound healing times showed that patients in the flap group achieved complete epithelialization significantly faster than those in the ADM group. The mean time to full wound healing was 72 ± 8 days in patients treated with ADM, compared to 23 ± 4 days in those who underwent flap reconstruction ($P < 0.05$). This delay in healing in the ADM group was expected due to the staged nature of the technique, which requires initial matrix integration before definitive skin grafting. Rather than interpreting this as a direct measure of inferiority, it should be considered a component of the overall treatment burden, highlighting the different trajectories of the 2 strategies.

Among ADM patients, no statistically significant difference in healing time or graft take was observed between STSG and FTSG subgroups ($P > 0.05$), although infection was more frequently observed in FTSG cases (3/8) compared to STSG (1/13), without reaching statistical significance.

Table 2
Oncological analysis.

	ADM group (Cases)	Flap group (Controls)
Tumor hystotype		
SCC	17	17
BCC	3	6
DFSP	1	0
MELANOMA	0	1 (in situ)
TNM SCC		
pTis	0	1
pT1	1	1
pT2	5	10
pT3	11	4
pT4m	0	1
GRADING SCC		
G1	0	0
G2	12	10
G3	5	7

Legend: N.A., not applicable; SCC, squamous cell carcinoma; BCC, basal cell carcinoma; DFSP, dermatofibrosarcoma protuberans.
*statistically significant.

Table 3
Reconstruction analysis.

ADM group (Cases)		
ADM type (n; %)	*Integra®*	19
	Nevelia®	2
Graft type (n; %)	STSG thigh	13
	FTSG arm	3
	FTSG groin	4
	FTSG supraclavicular	1
Mean Operative Time	*First stage*	41 ± 7 minutes
	Second stage	36 ± 3 minutes
	Total	77 ± 7.62 minutes
Flap group (Controls)		
Flap type (n; %)	Advancement flap	2
	Rotation flap	3
	Hatchet flap	12
	Transposition flap	1
	Regional fascio-coutaneous flap	5
	Buckett flap	1
Mean Operative Time	*One stage*	59 ± 5 minutes

The mean operative time was 41 ± 7 minutes for ADM-based reconstruction and 59 ± 5 minutes for flap-based reconstruction ($P < 0.05$). While ADM initially required a shorter operative time, it necessitated a secondary procedure for skin grafting, which increased the overall treatment duration. After accounting for the second surgery in the ADM group, the total mean operative time increased to 77 ± 7.62 minutes (mean duration of secondary procedure 36 ± 3 minutes). A statistical analysis using Welch's t-test confirmed that this difference remains highly significant ($P \approx 9.34 \times 10^{-11}$) (Table 3). This finding underscores the importance of evaluating not only the first procedure but also the cumulative operative time and number of anesthetic exposures required to achieve final healing.

Operative times were calculated excluding the minutes spent waiting for the results of any intraoperative frozen section histological examinations. Hospital stay was slightly longer in the flap group (2 ± 3 days vs. 1 ± 2 days in the ADM group, $P = 0.19$), particularly in cases where flap monitoring was necessary.

Table 4
Complication analysis.

	ADM group (Cases)	Flap group (Controls)
Prolonged serous drainage (n; %)	3; 14.2%	0
Infection (n; %)	4; 19 %	0
Graft faliure (n; %)	1; 4,7%	N.A.
Partial flap necrosis (n; %)	N.A.	4; 16,6%
Total flap necrosis (n; %)	N.A.	0
Wound dehiscence (n; %)	N.A.	2; 8.3%

Legend: N.A., not applicable.

The flap group included a variety of techniques, with hatchet flaps representing the majority ($n = 12$). Due to procedural heterogeneity, subgroup analysis by flap type was not feasible, and outcomes should be interpreted with caution.

Complication rates

Complication rates were comparable between the 2 groups, although the nature of complications differed (Table 4). In the ADM group, the most common issues included prolonged serous drainage ($n = 3$; 14.2%) and localized infections ($n = 4$; 19%), defined as clinical signs of infection requiring antibiotics and/or minor debridement. These events were likely related to the foreign-body response and delayed vascularization of the ADM. Regarding the second-stage procedure, one case (4.7%) of skin graft failure, defined as graft loss requiring regrafting or extended dressing care, was observed.

In the flap group, complications were mostly related to vascular perfusion, with partial necrosis ($n = 4$; 16.6%) and wound dehiscence ($n = 2$; 8.3%) being the most frequent. Partial necrosis was defined as limited tissue loss requiring debridement without total flap loss, and dehiscence as wound edge separation >5 mm. Some patients required secondary interventions, such as flap revision or minor debridement, but no cases of complete flap loss were recorded.

When stratifying patients by age (cut-off at 75 years), complication rates did not significantly differ between younger and older patients within each group. However, in the flap group, 2 elderly patients (>80 years) experienced minor cardiovascular instability postoperatively, requiring extended monitoring but not surgical delay. This suggests that, beyond wound-related complications, overall surgical tolerance remains a relevant consideration in fragile patients undergoing flap reconstruction. No correlation was observed between age and hemoglobin drop or anesthetic complications.

Aesthetic and functional outcomes

The evaluation of aesthetic outcomes showed no significant difference between the 2 groups (Figs. 4 and 5). The mean Vancouver Scar Scale (VSS)[11] score was 4.07 (SD = 1.75) in the ADM group and 4.92 (SD = 2.43) in the flap group ($P = 0.248$), indicating similar scar quality. Similarly, Patient Satisfaction Scores (PSS, 1–5 scale) were 4 in ADM patients and 4.5 in flap patients, reflecting comparable subjective aesthetic perceptions. The combined use of an objective, validated scar scale (VSS) and a patient-reported satisfaction score (PSS) represents a methodological strength, allowing assessment of both clinical and subjective outcomes.

In a subgroup analysis, no statistically significant difference in PSS was found between alopecic and nonalopecic patients ($P = 0.34$). In the ADM group, satisfaction was generally not affected by the absence of hair, likely due to the advanced age of most patients and the preexisting baldness in many cases. Nevertheless, hair restoration remains an important factor in

Fig. 4. Another case of a patient with SCC of the scalp: on the left, preoperative image of the lesion; on the right, the outcome 3 months after the final procedure, with ADM coverage followed by full-thickness skin grafting.

Fig. 5. A case of suspected basal cell carcinoma of the scalp (top), treated with excision and reconstruction using a double hatchet flap (middle), with the final result at 12 months postoperatively (bottom).

younger individuals or when defects are in the frontal or temporal regions, where scalp visibility is high.

Functionally, flaps provided thicker, more durable coverage, while ADM preserved adjacent tissue and allowed for a more natural skin contour following grafting. However, the thin appearance of grafted ADM sites was noted in some patients, particularly in those with large defects. Overall, the 2 approaches yielded functionally stable and aesthetically acceptable reconstructions, with flaps favoring durability and ADM favoring tissue preservation and contour restoration.

Need for additional procedures and cost analysis

While both techniques provided successful defect coverage, the need for additional procedures differed between the groups. In the ADM group, 100% of patients required a second-stage procedure for skin grafting, whereas 12.5% of flap patients ($n = 3$) required minor revisions due to partial necrosis or contour irregularities. This difference reflects the intrinsic staged nature of ADM and highlights the importance of considering not only surgical success but also the overall treatment burden, including the number of procedures, anesthetic exposures, and follow-up visits required to achieve complete healing.

A preliminary cost analysis indicated that ADM procedures had higher material costs due to the use of dermal matrices, while flap procedures required longer surgical time and longer hospitalization. Therefore, cost-effectiveness depends less on a single parameter and more on the interplay between material expenses, operative duration, hospital stay, and the likelihood of revision surgery. This variability underscores the need for individualized patient selection when balancing resource utilization and clinical outcomes.

Discussion

Healing and surgical efficiency

Scalp reconstruction presents unique challenges due to the region's limited tissue elasticity and the need for durable, aesthetic coverage.[13] This study compared the use of acellular dermal matrices (ADM) and local flaps, highlighting their differences in healing, complications, and surgical efficiency. One of the most notable findings was the difference in healing time. Flaps provided immediate coverage, facilitating rapid re-epithelialization and early wound closure. Conversely, ADM required a staged approach, involving an initial matrix placement followed by a secondary skin grafting procedure. This delay in complete healing is an inherent feature of ADM and was therefore expected; however, its systematic quantification in terms of days to epithelialization provides clinically relevant information for patient counseling and resource planning.[14]

The reduced operative complexity of the first stage and the avoidance of extensive flap dissection make ADM an appealing option for elderly or comorbid patients, in whom prolonged anesthesia may be poorly tolerated. At the same time, the necessity of a second-stage procedure means that the overall treatment burden—including cumulative operative time, repeated anesthetic exposure, and extended follow-up—is generally higher than with flap-based reconstruction. For this reason, total treatment trajectory, rather than initial operative time alone, should guide the reconstructive decision.

It is important to emphasize that in cases where defect resection includes periosteal removal to ensure oncologic radicality, ADM-based reconstruction requires drilling of the outer cranial table to create a bleeding wound bed, which is essential for matrix integration.[15] This step is not necessary in flap-based reconstruction, as flaps inherently consist of vascularized tissue.

Complications and morbidity

The overall complication rates were comparable between the 2 groups, but the types of complications differed. In the ADM group, the most frequent issues were prolonged serous drainage and localized infections, both of which are well-documented concerns in the use of biomaterials.[16] Infections were defined as clinical signs requiring antibiotics and/or minor debridement, and were likely related to the absence of intrinsic vascularization of ADM, which makes integration dependent on host tissue ingrowth and therefore more vulnerable to colonization. Despite this, no cases of complete failure were observed, and infections were manageable with conservative wound care.

In our series, infection was more frequently observed in cases treated with full-thickness skin grafts (FTSG), though without reaching statistical significance. This observation may suggest that graft thickness could influence matrix take or fluid accumulation, although larger series are needed to confirm this hypothesis.

In contrast, complications in the flap group were primarily related to vascularity, with partial necrosis and wound dehiscence being the most common. Partial necrosis was defined as nonviable tissue requiring debridement without total flap loss, while dehiscence was defined as wound edge separation >5 mm. These complications required secondary interventions in some cases but did not result in complete flap loss. Given that flap survival is highly dependent on robust vascularization, patients with prior radiation therapy, diabetes, or extensive oncologic resections are at greater risk of postoperative complications.[17] These findings highlight the need for careful patient selection and surgical planning to minimize vascular compromise.

Notably, stratification by age (>75 years) did not reveal a statistically significant difference in complication rates. However, 2 elderly patients in the flap group experienced mild cardiovascular instability in the perioperative period, indicating that surgical tolerance and systemic risk, beyond wound-related outcomes, remain crucial considerations in fragile patients.

Aesthetic and functional outcomes

Both techniques yielded comparable aesthetic outcomes, as indicated by similar Vancouver Scar Scale scores and patient satisfaction ratings. The concurrent use of an objective, validated scar assessment tool (VSS) and a patient-reported outcome measure (PSS) strengthens the reliability of these findings by capturing both clinical and subjective perspectives.

While flap-based reconstruction provided thicker, well-vascularized tissue, in some cases, it resulted in contour irregularities or bulkiness, which may require secondary revision. ADM-based reconstruction, while offering a more natural skin color match after grafting, initially had a thinner, grafted appearance that might be less favorable from an aesthetic standpoint. Functionally, ADM preserved adjacent tissue and offered good contour adaptation, making it useful in cases where local tissue laxity was insufficient for flap advancement. However, its lack of intrinsic tensile strength compared with vascularized flaps limits its use in high-tension areas or in larger defects requiring immediate structural stability.

An important aesthetic consideration is the presence or absence of hair. Local flap reconstruction within the scalp enables like-with-like defect repair, providing skin of similar thickness with hair-bearing properties.[18,19] In contrast, ADM-based reconstruction followed by skin grafting restores cutaneous coverage but does not replace hair follicles. This factor is particularly relevant in younger patients or when defects involve cosmetically critical areas such as the frontal hairline or temples. Conversely, in older patients—who represent the majority of individuals affected by scalp cutaneous tumors—and in bald patients, this aspect was generally negligible, as reflected in the Patient Satisfaction Scores (PSS). In our cohort, the absence of hair did not significantly influence patient satisfaction, likely due to the advanced age of most individuals and the prevalence of pre-existing baldness. Nonetheless, in younger or cosmetically demanding cases, the potential impact of alopecia should be carefully weighed in the reconstructive decision.

Clinical implications and surgical decision-making

The choice between ADM and flap reconstruction should be tailored to patient-specific factors, defect size, and reconstructive goals. ADM may be a preferable option in patients who cannot tolerate prolonged operative times or have limited donor tissue availability. It is particularly useful for intermediate-sized defects where a simple, staged approach can be planned.[20,21] On the other hand, flaps remain the gold standard for large or deep defects requiring robust vascularized coverage, particularly when single-stage reconstruction is desired to minimize treatment duration.

Importantly, this study does not aim to declare one technique superior to the other, but to illustrate how each approach may offer unique advantages depending on the clinical context. From a practical perspective, the findings highlight that ADM and local flaps should not be considered competing options but rather complementary tools within the reconstructive armamentarium. The final decision should integrate surgical feasibility, oncologic safety, patient comorbidities, and aesthetic expectations. By framing the choice as part of a broader reconstructive algorithm, this study provides clinicians with real-world parameters—healing trajectory, complication profile, and treatment burden—that can guide tailored surgical decision-making.

Limitations and future directions

This study has some limitations, including its retrospective design, limited sample size, and single-center setting, which may limit generalizability. Patient allocation to ADM or flap reconstruction was not randomized but based on clinical judgment, introducing a potential selection bias. In addition, the flap group included different techniques, precluding detailed subgroup analysis. Larger, prospective studies with extended follow-up are needed to assess long-term ADM integration, scar maturation, and durability. Future investigations should also incorporate multivariate analyses or matching strategies to adjust for confounders, as well as patient-reported outcome measures beyond simple satisfaction scores. Additionally, research should explore hybrid approaches that combine ADM with vascularized tissue, potentially optimizing reconstructive outcomes by leveraging the benefits of both techniques.

Conclusion

Both ADM and local flaps provide effective options for scalp reconstruction, each with distinct advantages and limitations. Flaps remain the gold standard for large or high-tension defects, offering immediate, vascularized, and hair-bearing coverage, though at the cost of longer operative times and donor site morbidity. ADM, in contrast, represents a less invasive staged alternative that preserves surrounding tissue and may be particularly advantageous in frail patients, those with limited donor site availability, or when histologic margins are uncertain, albeit with a longer healing period and a higher risk of localized infection. Rather than competing, the 2 techniques should be viewed as complementary components of a patient-tailored reconstructive strategy, with the final choice guided by individual patient factors, surgical expertise, and logistical considerations. Further prospective studies are needed to refine selection criteria, assess long-term outcomes, and explore potential hybrid approaches that combine the benefits of ADM and vascularized tissue.

Author credit

Ferruccio Paganini: Conceptualization, study design, data curation, manuscript writing (original draft), and critical revision. **Sara Matarazzo:** Data collection, surgical procedures, figure preparation, and manuscript editing. **Andrea Carugno:** Patient selection, surgical procedures, and contribution to discussion and literature review. **Beatrice Corsini:** Statistical analysis, data interpretation, and manuscript review. **Roberta Di Vincenzo:** Dermatological diagnosis, oncologic resection planning, and critical input on methodology. **Lorenzo Fresta:** Surgical planning, intraoperative documentation, and postoperative follow-up coordination. **Luigi Valdatta:** Supervision, project administration, and final approval of the manuscript.**Nicola Zerbinati:** Dermatopathological analysis, scientific guidance, and review of oncologic relevance.

Ethical approval statement

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975. Informed consent was obtained from all patients for being included in the study. The study was approved by the "Company Committee for participation in retrospective studies".

Declaration of competing interest

The authors declare no conflict of interest.

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