Is long-term post-operative monitoring of microsurgical flaps still necessary?

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Summary Autologous microsurgical flap reconstruction has become commonplace in most plastic surgery units, and the success rates of this procedure have markedly increased over recent years. However, the possibility of flap failure still needs to be considered. A review of the literature reveals that the critical period for flap-threatening complications is the first 24—48 post-operative hours; however, the window for the onset of these complications remains open for up to 7 days post-operatively. In this study, we focus on the timing of flap complications, aiming to elucidate the time period over which meticulous flap monitoring can positively contribute to flap salvage rates.

The relevant literature on the study topic was collated and reviewed in conjunction with the senior author's case series, which consisted of a total of 335 free flaps used during a 2-year period for breast and head and neck reconstruction or limb trauma. Patients' series were then divided into groups according to the complications timing. The correlation between the timing of complications and the flap salvage rate was investigated among the groups.

Overall analysis of both the literature and our own data on 335 free flaps showed a progressive reduction in flap salvage rate during post-operative days; the correlations between the times of complication onset and the flap salvage rates in all groups were significant up to the third post-operative day. The correlations between salvage rates and later complications were not significant. Our results suggest that hourly flap monitoring should be compulsory during the first 48 post-operative hours, but clinical monitoring four times daily should be sufficient thereafter.
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Introduction

Microsurgical reconstruction using autologous flaps has become one of the pillars of plastic surgery. Today, the success rate of microsurgical reconstruction is approximately 95%.[1–4] However, despite improved outcomes, the risk of flap failure is not yet negligible.[5–7]

There is no consensus in the literature regarding the duration of the high-risk post-operative period for flap vascular complications. Previous studies have shown that complications can develop up to 7 days post-operatively, but that the critical window of time for complications is 24–48 h.[8–11] Flap-threatening complications that may develop include vascular thrombosis, pedicle kinking, venous congestion and arterial spasm.[9] The probability of flap salvage is inversely related to the duration of ischaemia, and flap salvage becomes almost impossible after 12 h at the onset of the 'no-reflow' phenomenon.[4,10]

Microvascular flap reconstruction is expensive in terms of time and resources. Appropriately skilled personnel are needed to perform regular post-operative monitoring, with the aim of detecting early signs of flap failure.[4,8,10,12] Several post-operative protocols have been described; most of them require hourly assessments of relevant clinical parameters, and some require the use of expensive equipment.[4,13]

In this study, we report our series of recent microsurgical cases and the results of a literature review on flap salvage. We aimed to determine the time period for which frequent post-operative monitoring is required to prevent avoidable flap failures. To the best of our knowledge, there have not been any previous studies with the same aim.

Patients and methods

Data collection

After approval by our institutional review board, we conducted a retrospective analysis of the senior author's cases. The study included consecutive patients who underwent microsurgical reconstruction using autologous flaps between January 2013 and November 2015.

In accordance with our institution's post-operative monitoring protocol, all flaps were checked hourly for the first 48 h after surgery and, subsequently, every 2–3 h until patient discharge. The following assessments were performed and recorded: capillary refill, skin colour, cutaneous temperature and arterial Doppler signal. If a vascular complication was identified, the duration of ischaemia was determined, starting from the time of the previous flap assessment to after clamp release following re-exploration.

The PubMed, Scopus, Embase and Cochrane Library databases were used to identify the relevant literature. The following keywords were used in the search: flap monitoring, flap salvage, flap failure, flap re-exploration and microvascular thrombosis. The complete text of every work pertaining to the study topic was analysed, with a focus on the time to early-onset complications and salvage rate. Studies that did not report the onset times of the post-operative complications and the outcomes of the salvage procedures were excluded. Adverse events not related to flap surgery were not considered.

Data synthesis and statistical analysis

All data obtained from the literature and the review of our cases were standardised according to time of complication onset and flap salvage rate. The complication onset times were grouped into 24-h blocks of post-operative time for purposes of analysis. The data were analysed by one-way analysis of variance (ANOVA), followed by the F test, using the SPSS version 22 software (IBM Corporation, USA). A p value < 0.05 was considered statistically significant.

Results

A total of 335 free microsurgical reconstructions were performed; their details are reported in Table 1. No pedicle flaps were included in the study. Vascular complications developed in 31 (9.2%) flaps, and 14 of them could not be salvaged, resulting in an overall salvage rate of 52.8%. Table 2 shows the distribution of complications over time, with associated flap salvage and failure rates in our patients.

Table 3 shows a summary of the data from the literature review. The time to onset of complications in our case series was similar to the data reported in the literature. The overall analysis of our data and literature data found a significant correlation between the times of complication onset and the flap salvage rates, up to the third post-operative day ($p < 0.05$). Probably because of the small

Table 1 335 free flaps description: type of flap, indication and recipient site.

Indication	Recipient site	Flap	No. of flaps (%)
Trauma	Upper limb	ALT	2 (0,6)
	Lower limb	ALT	35 (10,4)
		DIEP	1 (0,3)
		Gracilis	2 (0,6)
		Forearm	6 (1,7)
Oncology	Head and neck	ALT	27 (8,1)
		LD	2 (0,6)
		Gracilis	3 (0,9)
	Breast	DIEP	182 (54,4)
		SGAP	48 (14,4)
		PAP	9 (2,7)
		TUG	18 (5,3)

Table 2 Number of complications by time and flap salvage rate; literature data.

Our experience	24 h			48 h			3 days			>3 days		
	TF	S	F	TF	S	F	TF	S	F	TF	S	F
31 flaps were explored	18	12	6	9	5	4	2	0	2	2	0	2

TF = total flap; S = saved flap; F = failed flap.

Table 3 Number of complications by time and flap salvage rate; literature data.

Authors	24 h			48 h			3 days			>3 days		
	TF	S	F	TF	S	F	TF	S	F	TF	S	F
Ho MW et al.[8]	17	12	5	2	0	2	7	0	7	6	2	4
Yang Q et al.[11]	26	14	12	18	4	14	3	0	3	\	\	\
Chang EI et al.[21]	14	8	6	61	50	11	\	\	\	\	\	\
Agostini T et al.[22]	1	1	0	\	\	\	\	\	\	\	\	\
Suominen S et al.[23]	17	10	7	\	\	\	\	\	\	\	\	\
Khansa I et al.[24]	39	28	11	\	\	\	\	\	\	\	\	\
Brown JS et al.[25]	31	26	5	1	0	1	3	1	2	5	2	3
Chen KT et al.[12]	93	79	14	10	8	2	5	4	1	5	3	2
Nelson AJ et al.[26]	\	\	\	\	\	\	\	\	\	10	8	2
Salgado CJ et al.[27]	\	\	\	\	\	\	\	\	\	10	5	5

TF = total flap; S = saved flap; F = failed flap.

number of cases, ANOVA did not find a significant correlation between salvage rate and the times of complication onset in the last group (p = 0.27). Table 4 reports the statistical analysis results for all groups.

Discussion

Microvascular tissue transfer is a reliable method for the reconstruction of complex surgical defects.[5] Microsurgical complications can be divided into two main groups as follows: early complications due to arterial or venous insufficiency and late complications. The most common late complications include fat necrosis and do not usually compromise flap survival. Early vascular complications are rarer but can lead to flap failure.[10,14] The average re-exploration rate of free flaps ranges from 6% to 14%, and despite re-exploration, a small number of flap failures occur.[14–16] The rate of failure appears to be affected by the time to detection of circulatory insufficiency and the duration of time until re-exploration is performed.[17–20] Early diagnosis of vascular insufficiency is known to be associated with successful flap salvage.[12] Studies have

Table 4 ANOVA analysis of flap salvage rate.

Timing	F test	p value
0–24 h	3.6	0.011
48 h	6.04	0.0007
3 days	2.97	0.026
>3 days	1.33	0.27

found that the majority of early complications are recorded during the first 24 post-operative hours and that the complication rate then declines over time.[8,11,12,21–27] Our retrospective analysis found that the flap salvage rate followed a similar trend.

In our review of the literature, only 10 papers satisfied our inclusion criteria. Of them, only five papers[8,12,25–27] reported the flap salvage rate/time beyond three post-operative days. One study[11] analysed rate/time up to the third day and another study reported data up to 48 post-operative hours.[21] Three papers[22–24] described the relationship for the first 24 post-operative hours. Several papers were excluded because of lack of information on the time of complication onset.

Considering together the data collected in the literature and our patient's series, we demonstrated a statistically significant association between the time of onset of the complication and salvage rate in all groups.[8,11,12,21–27] Prompt re-exploration of the flap during the first 48 h after surgery most likely accounts for successful flap salvage. The rate of flap salvage significantly decreased after 48 h (p = 0.0007). Our findings suggest that after 48 h, the number of flap assessments can be reduced to four times daily because of the decreased flap salvage rate. Although some late flap salvages were reported in the literature, we believe that finding is probably not statistically significant and could be attributed to chance. However, in their report on very late vascular-associated flap failures, which described their method for successfully managing those complications, Nelson et al. provided evidence that attempts at flap salvage must be performed, regardless of the time of complication onset.[26]

The decreased rate of flap salvage associated with late complications may be related to the no-reflow phenomenon, which generally appears after prolonged ischaemia and leads to flap failure despite adequate arterial inflow.[28] The biochemical basis of no reflow is not thoroughly understood.[5] The prolonged ischaemia triggers a metabolic cascade that results in irreversible endothelial damage. Within a few seconds of the cessation of inflow, stored ATP is depleted, leading to the breakdown of the Na–K pump. Cells becoming swollen because of changes in the balance of electrolytes constrict the vascular space and prevent blood flow. With a shift in cellular metabolism toward anaerobic conditions, inflammatory cytokines are released, leading to worsening vascular damage. After flap reperfusion, oxygen reacts with the products of anaerobic metabolism, and free radicals are formed, which leads to irreversible tissue damage.[5]

The primary reason for a low flap salvage rate of late complications might be based more on intrinsic characteristics of the flap instead of on the duration of ischaemia. That is, some late complications with ischaemia times shorter than 3 h might still be unsalvageable. In our opinion, re-exploration should remain mandatory in cases of suspected flap failure; however, in cases of late complications, anastomotic problems may not be present, meaning that no correctible cause can be found. Nonetheless, Salgado et al. demonstrated that successful flap reperfusion after a late failure of arterial anastomosis was still possible.[27]

In addition, the psychological impact of a late flap revision on the patient is an important consideration.[29]

After an immediate reconstruction procedure, the patient tends to be less affected by mutilation and more easily accepts a new body image.[30] A late flap failure can cause anxiety, which is difficult to manage. We only attempt a new flap to salvage the reconstruction if a technical reason for failure of the original flap can be identified. If another condition such as a thrombogenic disorder that might compromise flap survival is suspected, the patient needs comprehensive assessment before a new flap is attempted.

A reduction in flap assessment time could reduce the costs of post-operative management without reducing the rate of successful flap surgery or the overall salvage rate.[31] This issue has been thoroughly investigated by Subramaniam et al.[31]; the average cost of post-operative flap monitoring is of $180 (USD) for clinical observation. In addition, Sinha et al. have demonstrated that the reimbursement to the hospital for a free flap is often less than the real cost of the procedure.[32] Reducing the number of clinical observations, especially after 48 post-operative hours, can clearly reduce the cost of the procedure to the health service.

The main limitation of our study was the lack of uniformity in the literature. Although there were several articles on flap complications, few reported the exact time of the onset of complications and the rate of flap salvage and therefore were not included in our literature review. We combined the data from our case series with the data from the reports in the literature that we reviewed to increase the statistical strength of our study.

This study provides evidence on the relationship between the time of complication onset and the probability of flap salvage. We found that early complications are often related to vascular problems, which have a high probability of flap salvage and require close monitoring, whereas exploration of late flap failures has a low probability of success because of problems intrinsic to the flap. As discussed previously, the no-reflow phenomenon generally appears after 12 post-operative hours so that after two post-operative days, flap monitoring can be performed less frequently.

Conclusions

Our results suggest that hourly assessment of microsurgical flaps used in reconstruction should be compulsory during the first post-operative 48 h, and thereafter assessments performed four times a day might be sufficient. Although flap salvage is possible later than 48 h after surgery, less intensive monitoring performed after 48 h does not affect the rate of late flap salvage.

Conflict of interest

No conflicts of interest are reported.

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