Local flaps vs. free flaps for complex lower limb fractures: Effect of flap choice on patient-reported outcomes

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ABSTRACT

The optimal flap cover for managing open lower limb fractures is debated. Most studies have reported on surgical outcome but clinical outcome is not well recognised. We aimed to determine whether there are differences in patient-reported quality of life (QoL) outcome between local flap versus free flap.

All patients admitted with lower limb open fractures were retrospectively reviewed. Patient notes were assessed for demographics, time to fracture union, wound healing and patient-reported QoL with EQ-5D-5L alongside a novel flap assessment tool.

A total of 40 patients had flap reconstruction of their lower limb injury; 23 local flap (Group I) and 17 free flap (Group II). Average length of follow-up was 33.8 months. Group I - 10 revisions of flaps (43.5%) and 14 surgical complications (60.9%). Fracture union was 171 days and wound healing 130 days. EQ-5D index and EQ-VAS scores were 0.709 and 79.3, respectively. Group II - 8 revision of flaps (47.1%) and 12 surgical complications (70.6%). Fracture union was 273 days and wound healing 213 days. EQ-5D index and EQ-VAS scores were 0.525 and 57.2, respectively. Aesthetic appeal - 48% Group I vs. 66% Group II. Significant differences were found between the two flap groups with higher scores for daily living in Group I ($p = 0.007$) compared to higher overall flap ratings in Group II ($p = 0.049$). Both groups were comparable in terms of complications; while flap congestion and dehiscence were more common with free flaps statistical interrogation did not elicit significance ($p > 0.05$).

Local flap and free flap techniques offer distinct advantages. Local flaps have better surgical outcome and patient-reported QoL in the first few years post soft tissue reconstruction. Differences between local and free reconstructive techniques in terms of patient health and function are ameliorated in the longer term.

1. Introduction

Open lower limb fractures can be severe and limb-threatening, often involving lesions of both bone and soft tissues.¹ These injuries habitually require the expertise of both plastic surgeons to provide the soft tissue reconstruction, combined with orthopaedic team for fracture fixation.² However, the best suitable soft tissue reconstruction allowing both quick functional recovery and aesthetic outcome of the patient remains controversial.³ This information is vital for determining the true extent of surgical success and could potentially guide future surgical decision-making.⁴

Previous published evidence have compared various subtypes of flap cover (e.g. muscle versus fascia) in an attempt to identify those which provide the best chance of success.^{5–7} However direct comparison of patient reported outcomes and satisfaction between local and

free flap reconstructive methods is scarce. Although flap selection is dictated by type of injury and multifactorial, it is also important to understand the impact of flap selection on patient perceived outcome, as it would impact the overall success of surgery.⁸

The aim of this study was to determine whether differences in outcome exist between patients who had either free flap or local flap reconstruction. The primary focus was set on investigating the surgical outcome and secondary aim was to assess patient reported outcome.

2. Materials and method

This study involved a retrospective data analysis of all patients who presented to a single centre with open lower limbs fractures (tibia and/or ankle), which required a flap cover. Patients who had a primary wound closure requiring no flap were excluded from this study.

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Patients were grouped into two categories – Group I - Local flap and Group II - Free flap. Case notes were used to analyse patient demographic, injury specifications and choice of flap cover. The surgical outcome measures of interest included: the time until wound healing, flap related wound complications (including: infection, haematoma, congestion, dehiscence and necrosis), major complications, and time for bony union.

Patient reported outcome was assessed using EQ-5D-5L health questionnaires; a 5-dimensional assessment of mobility, self-care, usual activities, pain/discomfort, and anxiety/depression.⁹ This particular self-reported health and outcome measure was chosen due to its simplicity, user friendliness, descriptive capability and suitable application to lower limb injury. By this method, an EQ-5D health index value between –0.285 and 1 was obtained for each patient based on their questionnaire responses, with the lowest score of –0.285 representing an extremely poor health state and the highest of 1 being indicative of perfect health. We also used the EQ-VAS, a 0–100 visual analogue scale (0 = “the worst health”, 100 = “the best health”) which estimates current health state (Eqol).⁹

In addition patients were issued another health survey consisting of 11 questions related to current functional ability, to further assess their overall health status and wellbeing. These questions were more specific and sought to quantify the effect of flap surgeries on; aspects of daily living, symptom control, aesthetic appeal, overall flap rating, and more general quality of life. For the purpose of this study, the survey is referred to as the Flap Outcome Questionnaire (FOQ) (Supplementary Fig. 1).

3. Results

A total of 40 patients treated over a 2-year period were identified as suitable candidates for participation in this retrospective review (31 males and 9 females). All patients had sustained an open fracture of the tibia or ankle, which were treated with soft tissue reconstruction in the form of either a local or free flap (Table 1). All were previously independent and mobile.

Forty-three flaps (25 local vs. 18 free) were used altogether for the management of 40 open fractures (29 tibial vs 11 ankle), the majority of which were Gustilo type IIIB (67.5%). Fractures were of varied aetiology, mostly associated with falls and road traffic accidents (Table 2). A variety of muscle and fasciocutaneous (FC) flaps were utilised in both treatment groups; choice was determined by the leading plastic surgeon based on defect site, injury complexity, and the availability of reconstructive tissues. The 25 local flaps included 6 muscle and 19 FC, and the 18 free flaps included 5 muscle and 13 FC. The mean follow-up time was 33.8 months (range: 20.6–49.5).

Table 1
Overview of patients' characteristics.

Demographics	Group I N = 23	Group II N = 17
Sex, no. (%)		
Male	15 (65.2)	16 (94.1)
Female	8 (34.8)	1 (5.9)
Age, mean (years) ± SD	48.0 ± 21.3	36.7 ± 14.9
Smoking status, no. (%)		
Non-smoker	15 (65.2)	6 (35.3)
Ex-smoker	2 (8.7)	0 (0)
Smoker	6 (26.1)	11 (64.7)
Alcohol intake, no. (%)		
Within normal limits	19 (82.6)	12 (70.6)
Excess	4 (17.4)	5 (29.4)
BMI, mean (kg/m²) ± SD	25.1 ± 3.9	26.9 ± 5.5
Comorbidity, no. (%)	14 (60.9)	8 (47.1)

Table 2
Mechanism of injury and type of fractures.

Mechanism of injury	Group I N = 23	Group II N = 17	Total
Mechanism of injury, no. (%)			
RTA ^a	4 (17.4)	8 (47.1)	12
Fall	12 (52.2)	4 (23.5)	16
Crush	2 (8.7)	4 (23.5)	6
Other	5 (21.7)	1 (5.9)	6
Fracture type, no. (%)			
IIIA	1 (4.3)	2 (11.8)	3
IIIB	16 (69.6)	11 (64.7)	27
IIIC	0 (0)	1 (5.9)	1
Unspecified	6 (26.1)	3 (17.6)	9
Fracture location, no. (%)			
Proximal tibia	4 (17.4)	1 (5.9)	5
Mid tibia	7 (30.4)	6 (35.3)	13
Distal tibia	6 (26.1)	5 (29.4)	11
Ankle	6 (26.1)	5 (29.4)	11

^a RTA = Road Traffic Accident.

3.1. Surgical outcomes

Overall there were 26 flaps with complication (n = 43), giving an overall complication rate of 60.5%. Infection and necrosis were amongst the most commonly experienced problems in both flap types. In Group I - 14 out of 23 (60.9%) patients experienced one or more flap related complications, compared to Group II, which showed 12 out of 17 (70.6%). No statistical significant difference was found between the flap groups (p = 0.524). At the time of final follow-up, on comparison of both groups, Group I had lower average times for both wound healing (130 days) and fracture union (171 days) compared to Group II (213 days and 273 days, respectively) (Table 3).

There were 5 cases of deep infection, exclusive to Group I (p = 0.040). Besides this, there was no other significant difference in type of complication when comparing both groups, although flap dehiscence and congestion occurred more often within Group II. Overall there were 4 primary flap failures (10%), Group I – 4.3% failure rate and Group II – 17.6% (Table 3).

There were two major surgical complications; two patients, one in each group, had complete flap failure and significant wound complication. Subsequently the limb was not salvageable and required a below knee amputation (BKA). One patient from Group II had a major systemic complication and suffered a pulmonary embolism but subsequently recovered (Table 3).

There was no significant difference in complications based on the

Table 3
Comparison of complications between flap groups.

Complications	Group I N = 23	Group II N = 17	p-value ^a
	no. (%)		
Flap complications			
Infection	10 (43.5)	8 (47.1)	0.822
Haematoma	2 (8.7)	1 (5.9)	0.738
Congestion/thrombosis	2 (8.7)	4 (23.5)	0.194
Dehiscence	1 (4.3)	3 (17.6)	0.166
Necrosis	9 (39.1)	5 (29.4)	0.524
Overall complication rate	14 (60.9)	12 (70.6)	0.524
Major complications			
Primary flap failure rate	1 (4.3)	3 (17.6)	0.166
Below Knee Amputation	1 (4.3)	1 (5.9)	0.826
Re-operation rate	10 (43.5)	8 (47.1)	0.822
Wound healing (days)mean ± SD	130.4 ± 86.3	213.1 ± 192.7	0.093 ^b
Fracture union (days)mean ± SD	170.8 ± 105.8	273.2 ± 161.9	0.035 ^b

^a Chi-square test, significant p-value < 0.05.

^b T-test, significant p-value < 0.05.

timing of soft tissue cover, except for those with definitive coverage after 35 days ($n = 7$) who all had complications.

All fractures were regarded as united if there was bony bridge in 4 cortices in two standard views.⁽¹⁸⁾ For the purpose of this study 6 months was used a cut off for standard fracture union and at the time of study all 40 patients had completed a minimum of 6 months period. Excluding 2 patients who underwent BKA, 17 patients had clinical and radiological fracture union within 6 months of flap cover ($n = 38$), while a further 16 had delayed union. There was 1 case of non union in both Group I ($n = 22$) (4.5%) and Group II ($n = 16$) (6.3%). Three patients had insufficient information on the healing of their fracture available. However, at long-term follow-up all 33 patients who achieved union were able to fully weight bear without major difficulty or discomfort after an average of 6.9 months (Group I 5.5 months vs. Group II 8.6 months, $p = 0.037$).

3.2. Patient reported outcomes

Out of the 34 patients who were eligible to take part in the health survey, only 17 patients (Group I - 8; Group II - 9) agreed to complete the questionnaire, equivalent to a response rate of 50%. The average EQ-5D Index was 0.709 and 0.525 in Group I and II respectively ($p = 0.182$). EQ-VAS was 79.3 and 57.2 in Group I and II, respectively ($p = 0.052$) (Table 4a).

Responses to the FOQ showed a similar pattern to the results of the EQ-5D. Patients with local flaps scored higher on average in health measures related to daily living ($p = 0.007$), quality of life ($p = 0.146$), and symptom control ($p = 0.066$). Conversely, aesthetic appeal of the flap as well as overall flap ratings were higher for free flaps, although only the latter result was of significance ($p = 0.049$) (Table 4a).

As shown by Fig. 3, the biggest differences were seen in terms of daily living, symptom control, aesthetic appeal, and self-rated quality of life. The overall rating of patients' flap surgery was similar for both flap types.

Medium-term health outcome data was also available at 9.4 months for 13 patients (Table 4b). This included 8 patients in whom both medium- and long-term health data were available (Table 5). Comparison to long-term follow-up at 33.8 months showed remarkable global improvement in almost all studied health domains in the majority of patients.

4. Discussion

Most of the literature has reported a higher success rate of free flaps at 85–96%.^{4,10,11} Similar rates of success, up to 97%, have also been attained in local flaps.¹² This study has shown comparable results in local flaps (95%) but marginally lower results for free flaps (82.4%). The reason for this difference is open to interpretation but is likely to be multifactorial and many studies have shown results from free flap could be variable (90.6% success for local flaps vs. 75% for free flaps).^{12,13}

Some studies have suggested that free flaps are able to improve healing due to their rich, intact vascular supply compared to local flaps.⁶ However, to the contrary we found a significant difference in

favour of local flaps in terms of both wound healing and fracture union (Table 3). This might be due to the limited sample size of this study. Another possible explanation for such finding is that a notably larger proportion of patients treated with free flaps were active smokers. As documented by Adams et al., smoking is associated with an increased risk of flap failure, delayed union and non-union in patients with open tibial fractures.¹⁴ Interestingly, this is despite favourable characteristics within the free flap group in other areas such as generally younger age and less comorbidity, which one would normally associate with a higher healing potential.

In terms of complication, there were no statistically significant differences between the two flap types, although congestion and dehiscence were more commonly reported with free flaps (Table 3). Large-scale studies, such as those by Lorenzo et al., support this statement as free flaps have a well-known tendency for venous insufficiency.¹⁵ The results for overall complications, infection and secondary amputation also show great resemblance to the other outcomes of lower leg trauma documented in the works of Franken et al., with no difference between flap types.¹³ We did however note that delayed time from initial injury to definitive wound closure may precipitate increased risk of all complication, with all patients treated beyond 35 days suffering at least one flap-related problem. Although Franken and co-authors were able to accrue a slightly bigger sample, the ratio of local flaps to free flaps included within both studies was comparable.¹³ Of note, unlike their study, our results demonstrated no increase in the number of postoperative revisions with a free flap (Table 3). Furthermore, we found that deep infection occurred exclusively within the local flap group. It is feasible that this comes as a result of initial debridement procedure, which is usually more extensive with respect to free flap cover.

While the above surgical outcomes are undoubtedly important and have historically been the focus for determining treatment success, our study capitalises on previous study by incorporating the patient perspective. In order to gain a more complete picture of functional health status we chose to utilise two health scores; the validated EQ-5D and a locally devised FOQ designed to be more specific in determining the success of flap surgery.

4.1. Patient reported outcome

Within our study higher average EQ-5D index scores were calculated for the local flap group compared to the free flap group indicating marginally better health outcomes for local flap reconstruction (Figs. 1 and 2). Those in the local flap group generally had fewer or less severe problems across the dimensions of mobility, self-care, usual activity, pain/discomfort and anxiety/depression. Due to the small sample in this study, there was no statistical significance ($p > 0.05$) but there is consistent difference between the two groups as replicated in the other health questionnaire. The mean health scores of both flap groups, particularly those related to current quality of life (EQ-VAS) shows Group I scored higher than Group II with statistical analysis in the form of T-tests exemplifying borderline significance ($p = 0.052$) (Table 4a).

In terms of flap appearance, Quaba et al. noted that whilst local

Table 4a
Summary of long-term patient reported outcomes ($n = 17$).

	Group I $N = 8$ mean (SD)	Group II $N = 9$	p-value	Difference (95% CI)
EQ-5D Index	0.709 (0.267)	0.525 (0.274)	0.182	0.184(-0.096 to 0.464)
EQ-VAS	79.3 (19.2)	57.2 (23.2)	0.052	22.028(-0.17 to 44.22)
FOQ				
Daily living	18.1 (5.2)	11.1 (4.0)	0.007	7.014(2.22–11.81)
Symptom control	12.1 (4.8)	8.6 (2.3)	0.066	3.569(-0.26 to 7.4)
Aesthetic appeal	4.8 (1.9)	6.6 (2.7)	0.137	-1.806(-4.25 to 0.64)
Overall flap rating	7.6 (2.3)	9.6 (0.7)	0.049	-1.931(0.84 to -3.85)
Quality of life	6.9 (1.6)	5.6 (1.9)	0.146	1.319(-0.52 to 3.16)

Table 4b
Summary of medium-term patient reported outcomes (n = 13).

	Local flap N = 8 mean (SD)	Free flap N = 5	p-value	Difference (95% CI)
EQ-5D Index	0.557 (0.308)	0.309 (0.466)	0.268	0.248(-0.22 to 0.72)
EQ-VAS	70.9 (27.9)	39.8 (27.9)	0.077	31.075(-4.00 to 66.11)
FOQ				
Daily living	12.7 (6.8)	10.0 (7.0)	0.582	2.714(-8.19 to 13.62)
Symptom control	9.0 (6.1)	8.3 (5.5)	0.875	0.667(-8.83 to 10.16)
Aesthetic appeal	4.7 (3.6)	4.7 (3.0)	0.985	0.048(-5.47 to 5.56)
Overall flap rating	6.7 (3.3)	4.0 (4.0)	0.288	2.714(-2.78 to 8.21)3.143
Quality of life	6.1 (2.9)	3.0 (3.0)	0.154	(-1.46 to 7.74)

Table 5
Matched cases of patient health outcomes taken at 9.4 months vs. 33.8 months.

		Patient Reported Outcome Measure (PROM)						
		EQ-5D-5L		Flap outcome questionnaire (FOQ)				
Patient		EQ5D index	EQ-VAS/100	DL/25	PS/15	FA/10	FR/10	QoL/10
8 (Local)	Round 1	0.751	90	25	15	0	8	8
	Round 2	0.950	95	23	15	7	7	8
9(Free)	Round 1	-0.215	4	5	2	2	0	0
	Round 2	0.264	40	10	7	10	10	3
11(Local)	Round 1	0.811	85	18	15	9	9	8
	Round 2	0.950	99	23	15	7	9	9
13(Local)	Round 1	0.748	85	8	15	8	10	8
	Round 2	0.829	90	16	13	5	5	5
19(Free)	Round 1	-0.153	20	7	12	8	8	3
	Round 2	0.829	95	13	11	10	10	7
23(Local)	Round 1	0.725	70	9	4	4	6	6
	Round 2	1	100	25	15	6	9	8
27(Local)	Round 1	0.568	67	13	6	6	7	7
	Round 2	0.683	70	17	6	3	7	7
28(Free)	Round 1	0.628	50	n/a	n/a		n/a	n/a
	Round 2	0.481	40	9	6	6	8	5

Abbreviations: DL = Daily living; FA = flap appearance; FR = flap rating; n/a = data not available; PS = Physical symptoms; QoL = Quality of life.

Fig. 1. Box plots comparing EQ-5D index scores (Left) and EQ-VAS scores (Right) between flap types at 33.8 months follow-up.

flaps may limit scarring to one part of the body, they are still capable of causing notable cosmetic defect, in contrast to free flaps which offer the considerable advantage of providing tissue that can be specifically tailored to the defect.¹⁶ Despite the suggested inadequacy of local tissues, local flaps and free flaps within this study had equivalent aesthetic outcomes (47% for local vs. 47% for free) according to patient feedback

at medium-term follow-up (Figure IVb). This is in contrast to the aesthetic outcome achieved by Dolan et al. in lower limb reconstruction, where free flaps were rated 91/100 (91%).⁽⁴⁾ The difference in these figures is striking, however, could be due to the differences in follow-up, with Dolan et al. following-up patients for 8 years in their study, compared to our interim period of only 9.4 months (Table 4b). This

Fig. 2. Box plots comparing EQ-5D index scores (Left) and EQ-VAS scores (Right) between flap types at 33.8 months follow-up.

Fig. 3. Bar chart comparing the mean scores for the distinct health measures of the FOQ between local flaps and free flaps at long-term follow-up.

information implies that aesthetic status and patient satisfaction are very likely to change with time. In support of this, our longer-term follow-up of almost 3 years saw a marked increase in all dimensions of health status included within this study. In fact, scores for flap aesthetic at 33.8 months saw an increase to 66% for free flaps with an overall surgical satisfaction score of 96%. Meanwhile, the data for local flaps showed much less improvement in both of these areas (Table 4a). These findings suggest that while local flap outcomes are generally more encouraging in the short to medium term post-injury, time may bridge the gap in health outcomes for free flaps in the long term.

At initial follow-up daily living scores were comparably poor for both flaps, evidencing similar degrees of difficulty with mobility, completion of light to moderate activity, and increased dependence on others. Similarly, symptom control scores for both flap types were meagre, with a number of patients reporting pain, tenderness or

swelling of the flap site (Table 4b). Whilst these measures showed minimal difference at this time point, following a further 2 years of follow-up patients with local flaps had significantly improved function. This group was less limited in their daily activities ($p = 0.0007$) and had markedly better control of flap symptoms ($p = 0.066$) as compared to free flaps, which possibly remained more troublesome due to the increased complexity of trauma the time of the initial injury (Table 4a). Although QoL improves over time for both flap types, the sizeable differences in health scores reiterate local flap suitability for achieving better outcomes, both physically and mentally, at least in the earlier stages of healing.

It is accepted that there is 'no flap ideal for all circumstances', and that appropriate cover depends on various factors including location of the injury and patients comorbidities.^{1,2,17,18} Current guidelines and involvement of multidisciplinary (orthopaedic) teams have established

better management of these complex cases and potentially improve limb salvage.^{1,4,19,20} As shown in this study, patient-reported outcome remains poor in the more acute post-traumatic phase but shows remarkable improvement in the longer term.

5. Conclusion

The best suitable flap type for complex lower limb fractures management remains controversial and it is accepted that choice is guided by interplay of numerous factors. While this study has the limitations of its sample size, local flap seem to be associated with more positive patient-reported outcomes and fewer surgical complications compared to free flaps. However, disparities between these groups with regards to health and functional outcome are gradually reduced over time.

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Declaration of competing interest

The authors have no conflicts of interest to declare with respect to the submitted manuscript.

Appendix A. Supplementary data

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