Early and long-term outcomes following long posterior flap vs. skew flap for below knee amputations

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What this study adds

A below knee amputation can be fashioned using a long posterior flap, or skew flap. Contemporaneous studies comparing the two are lacking. We review both short and long-term outcome of patients who have undergone BKA by either technique. This study suggests that rates of residual limb failure (requiring surgical revision) are equal between the two surgical methods used. However, functional outcomes in unilateral amputees using a prosthetic limb were better in those who had received a long posterior flap amputation.

Abstract

Introduction

A Below Knee Amputations (BKA) can be undertaken using either a long posterior flap (LPF) or skew flap (SF). Data comparing outcomes between the two are scant.

Objectives

The aim of this study was to compare outcomes between the LPF and SF over a 13-year time period.

Design

Retrospective observational cohort study.

Methods

Consecutive patients undergoing a BKA with the LPF or SF method during a 13-year period at one hospital were identified. Both techniques were performed regularly depending on tissue loss and surgeon preference. The primary outcome was surgical revision of any kind. Secondary outcomes included revision to above knee amputation (AKA), length of hospital stay (LOS) and mortality. A smaller cohort of patients who were alive and unilateral BK amputees were contacted to ascertain prosthetic use and functional status.

Results

242 BKAs were performed in 212 patients (125 LPF and 117 SF; median follow up: 25.8 months). Outcomes for the two groups were equivalent for surgical revision of any kind (LPF: 27 vs SF: 31; $p = 0.373$), revision to an AKA (LPF: 18 vs SF: 14; $p = 0.576$), LOS (LPF: 29 days vs SF: 28 days; $p = 0.827$), and median survival (LPF: 23.9 months vs SF: 28.8 months; $p = 0.894$). Multivariate analysis found amputation type had no effect on any outcome. Functional scores from a smaller cohort of 40 unilateral amputees who were contactable demonstrated improved outcomes with the LPF compared to the SF ($p = 0.038$).

Conclusions

Both techniques appear equivalent for rates of surgical residual limb failure. Functional outcomes may be better with the LPF.

Keywords: Skew flap, Long posterior flap, Below knee amputation

Introduction

Below knee amputations (BKA) are frequently performed on patients with end-stage chronic limb threatening ischaemia and/or complications of diabetes.(1–4) The two methods for constructing the myocutaneous flaps are the long posterior flap (LPF) and skew flap (SF). The LPF was first proposed by Burgess and Romano in the early 1970's, and is the most frequently used technique.(5,6) However, the scar lies directly over the suture line of the gastrocnaemius tendon and tibial periosteum, which represents a vulnerable point prone to breakdown. In 1982, Robinson *et al*. described the SF, comprising an anteromedial and posterolateral skin flap, which were demonstrated to have a favourable blood supply on thermography.(7,8) The resultant skin wound was taken off the high-risk junction of gastrocnaemius and tibia. However the skin flaps lose all blood supply from deeper tissues, are therefore at risk of ischaemia, and more dead-space is created than with the LPF.

A recent Cochrane Review identified only one old trial comparing LPFs and SFs.(9,10) This multicenter study of 191 patients from 1991 demonstrated equivalent short and long-term outcomes between the two techniques.(10) However, recent concerns have been raised locally that the muscular flap on SF residual limbs have a greater tendency to 'fall off' the tibia, which can result in a bulbous posterior aspect of the residual limb, and make prosthetic fitting challenging. Furthermore, indications for amputation have changed over recent years, with a greater proportion of patients with diabetic foot disease, and current limb appliances technique are more advanced.(11–13) Contemporaneous studies comparing LPF with SF are lacking, and the investigation of different BKA stump healing depending on amputation type was selected as a research priority in the recently published Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischemia (14). The aim of this retrospective observational cohort study was therefore to compare the short and long-term outcomes of LPF with SF.

Methods

This study is reported *as per* the STROBE (Strengthening the Reporting of Observational Studied in Epidemiology) recommendations [Appendix 1].(15)

Patient identification and baseline demographic data collection

Local audit approval was obtained prior to commencing the study (reference number SA-774-17). All BKA procedures within a single center in South Wales, UK, serving a population of over 600,000 patients, were retrospectively reviewed from 26th October 2006 to 2nd April 2019 through an electronic search of the operating theatre database. Patients operated on under the Vascular Surgery team were included; those performed by the Orthopedic team were excluded. The following data were collected for each patient: age, sex, indication for surgery (rest pain, tissue loss), comorbidities (diabetes, renal failure, ischaemic heart disease (IHD), history of stroke) and smoking status (ex or current smoking). Full blood count, albumin and renal function results immediately before to surgery were also collected. The type of BKA operation performed (LPF vs. SF) was recorded. The study time period was divided into four equal quarters, and the number of LPFs vs SFs were compared for each period, to see if practice had changed with time.

Intervention

Ten consultant vascular surgeons oversaw or performed all operations, of which 4 surgeons would routinely perform a LPF, 4 would perform a SF, whilst 2 had no fixed preference. All were fully competent in both techniques. 34 individual trainees were primary operators for 119 cases, of which their amputation preference was available for 95 cases. If tissue loss pattern dictated that a specific amputation technique was required, this was performed irrespective of surgeon preference. When either technique was feasible with the pattern of tissue loss, surgeon's preference was used to determine the amputation technique.

Surgical technique for both LPF and SF were similar between all surgeons. The operations were performed as previously published.(5,16) Briefly, for SF amputations an equal anterio-medial and posterior-lateral semicircular fascio-cutaneous flap was raised. The gastrocnemius muscular flap was then raised, which was shaped similar to that of a LPF. Other operative procedures were equivalent between LPF and SF. A tourniquet was used, and a nerve catheter placed, according to surgeon preference.

Outcomes

All patients were followed up using the hospital electronic database 'Clinical Workstation' and the 'Welsh Clinical Portal', which links to GP records, operative records and clinical notes via the Welsh NHS database. Mortality data for the whole of the United Kingdom is obtained via links to the Office for National Statistics. The following outcomes were captured for all patients:

1. Residual limb debridement/revision, remaining as a below the knee amputation
2. Revision to above knee amputation (AKA), or through knee amputation (TKA)
3. Inpatient length of stay following index amputation
4. Mortality

Data were also captured on subsequent contralateral amputation. The primary outcome was defined as a composite of any BKA surgical revision, including residual limb debridement/revision (remaining below the knee), or AKA/TKA.

All follow up data were recorded up to the 9th May 2019, and for those who were alive and/or had not undergone revision surgery, follow up was truncated at this time. This method has potential to introduce bias, as the patients were not contacted at the time of follow up truncation, and in theory, an interval amputation/revision may have been undertaken since the last formal contact with the vascular team. The last known follow up date with the vascular team was therefore also collected. A follow-up index (FUI) was calculated for each patient; this is a ratio of ‘time from surgery to follow up with vascular team’ against ‘time from surgery to follow up truncation’, as previously described.(17) A FUI of 1 is used for patients with a known outcome at the time of follow-up truncation (applicable to all those who have undergone revision surgery, or died). All other FUI figures are by definition between 0 and 1, with figures closer to 1 being at less risk of bias.

Prosthetic usage was examined within a specific cohort of unilateral BKA amputees who had sufficient time for rehabilitation and fitting of artificial limb prosthesis. Patients were contacted from December 2017 until June 2019. Patients who were bilateral amputees, had a revision of their BKA to AKA, and those who had been operated on within the last six months were all excluded. Prior to attempted contact, electronic records were carefully checked to ensure the patient was alive. Patients were contacted by telephone, and provided verbal consent prior to their interview. Up to three separate attempts, at different times, were made to contact each patient via telephone. Patients who could not be contacted after three attempts were considered uncontactable. The Orthotics and Prosthetics Users Survey (OPUS)(18) [Appendix 2] lower extremity tool was used to quantify the usage of a prosthetic limb (if used) and the patients’ ability to undertake activities of daily living (ADLs). 20 ADLs are rated on a 5-point scale ranging from 1: ‘very easy’ to 5: ‘cannot perform activity’ and are scored accordingly (0-4). A greater score implies better functioning with ADLs. The maximum score is 80.

The outcomes captured for patients in this subgroup were:

1. Time spent using prosthesis, (hours/week)
2. OPUS score

For this subgroup the BLARt (Blatchford Allman Russell tool) score was retrospectively calculated for each patient.(19) This tool gives individual patients a score, ranging from 0 to 34, with higher scores indicating a reduced likelihood of achieving independent ambulation. Variables include patient demographics, co-morbidities, pre-amputation functional status, level of amputation and cognitive capacity.

Statistical methods

The Chi-square test was used for categorical variables, continuous variables were tested for normality using the Shapiro-Wilk test and then between group comparison undertaken using the unpaired Students t-test or Mann-Whitney U test as appropriate. Survival analysis and hazard analysis for revision of any kind and revision to AKA were undertaken using Kaplan Meier curves with the Log Rank test.

A sample size estimation using data derived from this cohort was undertaken using a web based sample size calculator.(20) For these calculations alpha was set at 0.05, and power at 80%. A similar sample size calculation was done based on data from the one previously published RCT of LPF vs SF (10).

Univariate analysis of risk factors for the need for revision (of any kind) was performed using cox-regression analysis and risk factors with a p<0.1 were further analysed. These risk factors identified were then subject to ‘backward’ multivariate analysis with significance set at $p<0.05$. A secondary multivariate analysis with amputation type (LPF vs. SF) forced into analysis was planned *a priori.*

All analyses, except for the sample size estimation, were performed using IBM SPSS (Statistical Package for the Social Sciences) software; version 24.

Results

Baseline demographics

212 patients undergoing 242 consecutive BKAs were identified. 125 LPF amputations (104 patients) and 117 SF amputations (108 patients) were performed (figure 1). There was a non-significant trend towards a greater number of LPF amputations being performed at in the first quarter of the study period, but this ratio was almost 1:1 for the remainder of the study [Appendix 3]. 30 patients underwent bilateral amputations during the study period; 13 with LPFs for both limbs, 9 with a SFs for both limbs, and 8 had a LPF and SF. Consultant were primary operators in 113 (46.7%) of the cases. 170 (70.2%) of cases were done according to the surgeons preferred preference (data not available for 24 (9.9%) cases). Baseline demographic data and indication for surgery were equivalent between the groups (table 1). 40 (16.5%) of limbs had undergone previous open surgical revascularisation, and 106 (43.8%) had undergone prior endovascular revascularization (10 (4.1%) had both open and endovascular revascularisation). Amputations were performed for non-septic CLTI on 137 (56.6%) limbs, and foot sepsis on 105 limb (43.4%). Follow up was for a median of 25.8 months (IQR 8.6 - 55.7). The FUI was 1 for mortality data, and 0.96 (range 0.17 to 1) for surgical revision data.

Outcomes

The median length of stay was 29 days (IQR 18 - 46) for the LPF group and 28 days (IQR 20 - 45) for the SF group (p = 0.827). 30-day mortality was equivalent between the two groups (LPF: 6 (4.8%), SF: 6 (5.1%), p = 0.906), as was in-hospital mortality (LPF: 9 (7.2%), SF: 5 (4.3%), p = 0.330). Stump infections were noted in 26 (20.8%) LPF wounds and 20 (17.1%) SF wounds (p = 0.463). Non-infective wound complications occurred in 25 (20.0%) LPF wounds and 34 (29.1%) SF wounds (p =

0.101).16 (54.7%) patients died during the follow up period, 56 in the LPF group and 60 in the SF group. Median survival for LPF and SF groups were 23.9 (IQR 6.4 - 55.4) and 28.8 (IQR 11.8 - 56.3) months respectively (p = 0.894).

A total of 58 (24%) limbs required revision of any type; 27 (21.6%) in the LPF group and 31 (26.5%) in the SF group (figure 2; p = 0.373). 32 (13%) of these were revision to an AKA (no patient had a revision to a TKA); 18 (14.4%) in the LPF group and 14 (12.0%) in the SF group (figure 3; p = 0.576). The rates of revision of any type within 30 days (LPF: 15 (12.0%) vs SF: 18 (15.4%); p = 0.443), 90 days (LPF: 19 (15.2%) vs SF: 27 (23.1%); p = 0.119) and 6 months (LPF: 20 (16.0%) vs SF: 27 (23.1%); p = 0.164) were equivalent between the two groups.

A sample size calculation was performed based on the above data. 2386 patients would be required to adequately assess if the effect size reported herein for 'revision of any type' were true. Similarly 6242 patients would be required for the outcome of 'revision to above knee'. Using effect size data from the one RCT of LPF vs SF (10), the required sample size would be 8034 for 'revision of any type' and 3472 for 'revision to above knee'.

Regression analysis

Univariate analysis of baseline variables identified the following variables predicted increased likelihood of revision of any kind (p value <0.1): male sex, absence of diabetes, history of smoking, hypertension, absence of tissue loss, higher levels of albumin and previous open revascularisation (table 2). The technique used for amputation was not a significant predictor (p = 0.401). The multivariate analysis identified that hypertension (HR 3.042, 95% CI 1.402 - 6.600; p = 0.005) and previous open revascularisation (HR 1.904, 95% CI 1.045 - 3.470, p = 0.035) increased the likelihood of revision whilst diabetes reduced the risk (HR 0.445, 95% CI 0.256 - 0.776, p = 0.004). When amputation technique was forced into this model, it remained insignificant as a predictor (p = 0.553).

Functional outcomes

A total of 60 patients were eligible for telephone consultation for OPUS scoring, of which 40 (67%) responded (LPF group: 17; SF group: 23; figure 4). Median follow-up time for telephone consultation for LPF was 23.7 (range 8.3-73.9) months, and for SF was 29.2 (range 9.0-94.5) months. Baseline demographic data and indication for surgery are presented in table 3; the groups were well matched except for their mean WCC (greater in the LPF group; p = 0.013).14 (82%) from the LPF group and 17 (74%) from the SF group were using a prosthesis, (p = 0.707). Mean BLARt scores were equivalent between the groups (LPF: 10.94+/-SD 2.38 vs. SF: 12.70+/-4.23; p = 0.105). The mean number of hours per week using a prosthesis was 73.5 +/- 24.5 for the LPF group and 72.0 +/- 41.7 for the SF group (p = 0.906). The mean OPUS score for those using their prosthesis was significantly greater in the LPF (33.7 +/- 10.7) group compared to the SF group (25.4 +/- 10.5; p = 0.038).

Discussion

This retrospective cohort study has demonstrated no significant difference between amputees undergoing a LPF or SF in terms of surgical revision. On multivariate analysis, previous open revascularisation and hypertension predicted an increased likelihood for revision, whilst diabetes had a protective effect. Amputation type had no effect on time of prosthetic usage, although there was significantly better functioning in the small subset of patients with a LPF who underwent telephone interviews. This cohorts overall revision, reputation rates, and mortality are comparable to published data.(21–24)

Robinson’s description of, and rational for, the SF having a postero-lateral and an antero-medial flap was based on the distribution of the sural nerve artery and saphenous nerve artery.(7,16) This explains why the post-amputation reduction in transcutaneous partial oxygen pressure ($TcPO_2$) in the resultant flaps following LPF is greater than following SF amputation.(25) Other theoretical benefits of the SF include avoiding an incision over the suture line of gastrocnaemius with the tibia, the avoidance of ‘dog ears’ which are common in LPFs, and a potentially improved contour of the residual limb.(10,26)

Only one randomized control trial (RCT) comparing outcomes in LPF vs. SF was identified by a recent Cochrane Review; a multicenter RCT enrolling 191 patients with PAD published in 1991.(10) This trial reports no significant differences in primary healing, wound edge necrosis, subsequent AKA, length of stay, rate of prosthetic limb fitting, mobility and mortality between the groups. However, all surgeons within this study were new to the SF technique, which may have impacted results. In addition, the results are not contemporaneous. An observational study comparing outcomes of LPF and SF (n=353 patients) was published prior to this RCT.(26) These authors found significantly faster wound healing, and a non-significant trend towards reduced conversions to an AKA, in the SF group. There were no long-term outcomes reported.

Diabetes was associated with a reduced risk of residual limb revision, in contrast to other studies where it had no effect on revision rates.(27–29) It is likely that a significant number of diabetic patients underwent a BKA for either crural vessel PAD or diabetic foot sepsis (or both), with good proximal blood supply and therefore a reasonable chance to heal. The presence of tissue loss was associated with a reduced risk of surgical revision on univariate analysis, but a significantly higher proportion of patients with tissue loss had diabetes. This most likely explains the presence of this confounder, and why its significance is lost on multivariate analysis. Previous open revascularisation was noted as a risk factor for a greater likelihood of residual limb failure. This is consistent with a number of other papers.(30) Hypertension was also a significant predictor of surgical revision. It is a well-established major risk factor for PAD, although has not been identified as a significant variable for surgical revision in other publications.(28,29,31–33) Its association with an increased surgical revision rate is probably as a proxy marker of significant PVD, rather than a direct effect of hypertension on wound healing.

It was impossible to consistently tell from the operation notes if a decision on amputation type was dependent on pattern of tissue loss, or if either flap could have been constructed. This is a weakness of this retrospective review. It was possible to analyse if the outcomes for surgeons performing their ‘preferred’ amputation type effected outcomes, which it did not. It is possible that certain patients would have been unsuitable for a LPF, due to posterior tissue loss, or SF due to anterio-medial tissue loss. However, estimates of the consultant surgeons involved in the operations are that <5% of the cohort had tissue loss mandating a specific amputation type.

This study has a number of strengths. The absence of data on outcomes after different BKA types was highlighted in the recent Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischemia, which made a research recommendation to: “Investigate whether there is a difference in stump healing between the skew flap, long posterior flap, and equal anterior and posterior flap techniques of BKA”.(14) Whilst our center does not do the latter technique, these data add significantly to the literature on LPF versus SF. It included data from patients over 13 years, with a large number of patients. All consultant surgeons were skilled in both techniques, and with approximately equal balance between those favoring LPF and SF. Follow-up time was long and captured a number of events in both groups. The FUI was 1 for mortality (due to robust linking of electronic records with both Welsh, and UK-wide patient databases) and 0.96 for surgical outcomes following amputation, which implies a very good electronic follow up, consistent with our previous experience of using the local electronic database.(34) Furthermore, the OPUS questionnaire captures both an objective measure of prosthetic usage (hours/week using the prosthesis) and a subjective measure (questionnaire on ADL activities).(18)

However, it suffers with numerous biases as is ubiquitous with retrospective studies. Whilst operative technique was pretty uniform for all operators, the use of a tourniquet varied depending on surgeon preference, as did the use of nerve catheters for post-operative pain, which are potential confounders. Operations performed by orthopedic surgeons were not collected, and it could be that a difference exists for their patient population. Surgeon preference was collected for most of the operators performing the surgery, however it could be considered oversimplistic to assume every surgeon can be clearly defined as preferring one specific amputation type over another. Whilst albumin levels were recorded, it is not a robust measure of nutrition, and the unit does not routinely run assays on more accurate markers (e.g. pre-albumin).(35) Three patients were excluded from the study, as the method of surgical technique used was not documented. Data is only linked to the Welsh NHS, and patients moving out of area might have had subsequent procedures elsewhere which would have been missed.

Regarding the cohort of patients approached for the questionnaire, there is significant selection bias. Follow-up of amputation patients to gather data on functional outcomes is difficult.(36) Mortality rate is high, and a number of patients either had revision to an above knee level or had bilateral amputations. The response rate of unilateral alive BKA amputees was 66.7%. Most of this was because patients were considered uncontactable; only 3 patients successfully contacted declined to partake with the study (figure 4). The OPUS questionnaire, whilst being validated, is susceptible to subjective bias. It also fails to distinguish exact causes behind difficulty with ADLs, which may due to other co-morbidities rather than specific issues with the residual limb. Therefore, whilst a significant difference was found between the two groups in terms of OPUS outcomes, this finding should be interpreted with caution. This is despite both groups having a similar BLARt score, which suggests their likelihood of ambulating is approximately equal. It is also worth highlighting that the care delivered to the amputees is broadly unchanged over the recent years; whilst new interfaces and components have been developed during the study time, the overall provision and service is very similar, and unlikely to have been a source of bias. Further research is required to identify if the trend identified in this cohort represents a true difference in long-term outcomes between the amputation types. It should be noted that the one RCT of LPF vs. SF found a non-significant trend towards better prosthetic usage and ambulation in the SF group.(10)

However, despite these limitations, these data suggest it is highly unlikely that there is a significant difference in terms of surgical revision rates between the two amputation types, consistent with the prior RCT. This would imply that the value of any future RCT to compare the two types in terms of surgical success is marginal, and huge numbers of patients would need to be enrolled according to the power calculations presented above. Should an RCT be contemplated, then these data would suggest that the primary outcome should be one of functionality, or stump suitability for limb fitting. Currently surgeons should be competent with both techniques, to accommodate for varying patterns of tissue loss. Whilst this study identified an advantage with the LPF in terms of overall functional outcomes, these data are prone to significant biases, and it is reasonable to offer either technique routinely.

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Ethics: Ethical approval was not required for this study.

Declaration of conflicts of interest: The authors declare no conflicts of interest.

Tables

Table 1.

	LPF	SF	P value
Total limbs (patients)	125 (104)	117 (108)	NA
Male	92 (73.6)	87 (74.4)	0.893
Diabetes	91 (72.8)	87 (74.4)	0.783
IHD	49 (39.2)	60 (51.3)	0.059
Stroke	19 (15.2)	12 (10.3)	0.25
Smoking	69 (55.2)	62 (53.0)	0.730
Hypertension	97 (77.6)	93 (79.5)	0.625
Renal failure	31 (24.8)	25 (21.4)	0.527
Tissue loss	98 (78.5)	93 (79.5)	0.836
Age - years	68+/-12.3	66+/-10.9	0.154
Albumin (g/L)	25.5+/-7.0	25.3+/-7.1	0.781
Haemoglobin (g/dL)	11.0 (29.5-12.4)	10.6 (9.1-12.0)	0.241
White cell count (10^9/L)	11.6 (69.0-15.5)	10.5 (8.5-14.2)	0.182
Creatinine (µmol/L)	78 (64-101)	77 (64-104)	0.715

Data presented as n (%), mean+/-SD or median (IQR). LPF = Long Posterior Flap, SF = Skew Flap, IHD = ischaemic heart disease, NA = Not Applicable.

Table 2.

	Univariate analysis			Multivariate analysis		
Variable	**Hazard Ratio**	**95% CI**	**P value**	**Hazard Ratio**	**95% CI**	**P value**
SF amputation	1.248	0.745 - 2.091	0.401	1.3321	0.788 - 2.251	0.284
Male sex	1.909	0.937 - 3.890	0.075*	2.131	1.005 - 4.515	0.048
Diabetes	0.367	0.219 - 0.616	<0.001*	0.282	0.163 - 0.488	<0.001
IHD	1.415	0.845 - 2.370	0.187			
Stroke	1.026	0.465 - 2.262	0.950			
Smoking	1.565	0.916 - 2.675	0.101			
Hypertension	1.913	0.906 - 4.040	0.089*	2.744	1.254 - 6.006	0.012
Renal Failure	1.203	0.659 - 2.196	0.548			
Tissue loss	0.515	0.298 – 0.892	0.018*	0.641	0.353 - 1.162	0.143
Age - years	0.991	0.970 - 1.012	0.391			
Albumin (g/l)	1.038	0.998 - 1.079	0.063*	1.021	0.979 - 1.064	0.337
Haemoglobin (g/l)	1.005	0.893 - 1.130	0.940			
White Cell Count (10^9/L)	0.989	0.949 - 1.031	0.600			
Creatinine (µmol/L)	1.000	0.996 - 1.003	0.849			

Table 2. IHD = ischaemic heart disease, CI = confidence interval, SF = Skew flap. * indicates those variables carried over to multivariate analysis.

Variable	LPF	SF	P value
Total	17	23	
Male	12 (70.6)	16 (69.6)	0.944
Diabetes	15 (88.2)	18 (78.3)	0.412
IHD	8 (47.1)	10 (43.5)	0.822
Stroke	2 (11.8)	1 (4.5)	0.379
Smoking	8 (47.1)	10 (43.5)	0.822
HTN	16 (94.1)	17 (73.9)	0.096
Renal failure	5 (29.4)	4 (17.4)	0.368
Tissue loss	16 (94.1)	18 (78.3)	0.165
Age - y	67.4+/-12.4	66.3+/-10.8	0.765
Albumin (g/L)	22.7+/-6.5	25.6+/-7.1	0.218
Hb (g/dL)	10.8+/-2.3	10.4+/-2.1	0.625
White cell count (10^9/L)	14.1+/-6.0	9.9+/-2.8	0.013*
Creatinine (µmol/L)	74 (69-98)	69 (57-111)	1

Table 3. Data presented as n (%) or mean+/-SD or median (IQR) unless stated otherwise. Categorical variables: male, diabetes, IHD, stroke, smoking, HTN, renal failure and tissue loss. Continuous variables: age, albumin, Hb, white cell count and creatinine. * indicates significant differences in variables. HTN = Hypertension, IHD = ischaemic heart disease SF = skew flap LPF = long posterior flap

Figure Legends

Figure 1. Flowchart of patients undergoing skew flap (SF) and long posterior flap (LPF), and subsequent surgical revisions. Note 8 patients had bilateral below knee amputations with different techniques.

Figure 2. Cumulative revision free Kaplan Meier survival estimate of time to surgical revision of any type (years) after skew flap (SF) and long posterior flap (LPF) below knee amputation. There were a total of 58 surgical revisions in 56 patients.

Figure 3. Cumulative above knee amputation (AKA) free Kaplan Meier survival estimate of time (years) after skew flap (SF) and long posterior flap (LPF) below knee ampuation. There were a total of 32 AKA revisions in 31 patients.

Figure 4. Flowchart of unilateral below knee amputation patients undergoing Orthotics and Prosthetics Users Survey (OPUS) of prosthetic usage.

Table Legends

Table 1. Baseline characteristics and demographics of patients who underwent a below knee amputation comparing skew flap (SF) and long posterior flap (LPF) technique.

Table 2. Univariate and multivariate analysis comparing the effect of baseline variables on the likelihood of surgical revision, of any kind, after below knee amputation surgery using a cox regression model comparing long posterior flap (LPF) and skew flap (SF.)

Table 3. Baseline demographics and characteristics of unilateral below knee amputation patients studied who responded to the Orthotics and Prosthetics Users Survey (OPUS) questionnaire comparing skew flap and long posterior flap technique. 40/60 unilateral below knee amputation patients responded to OPUS questionnaire in a single centre.

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