

Skew flap versus long posterior flap on below-knee amputation in patients with peripheral vascular disease

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Background/Aim: Below-knee amputation (BK) is the most proximal amputation that is still associated with a good rehabilitation procedure. All variations of the transtibial amputation are designed to provide adequate distal end padding and produce a cylindrical stump that can be readily suitable for prosthesis. The aim of this study is to compare the skew flap and the long posterior flap below-knee amputation in patients with peripheral vascular disease in terms of stump healing, wound infection, reamputation rate, and mobility with a prosthetic limb as outcome measures.

Patients and methods: Fifty patients with chronic atherosclerotic occlusive disease of the lower extremity and critical ischemia (intractable rest pain, ulcer or gangrene) for whom no other treatment options remained and in whom below-knee amputation is indicated are included in the study. Patients were randomized into two groups. Group 1 underwent Skew Flap BKA; Group 2 underwent long posterior flap BKA. The two groups will be compared in terms of stump healing, wound infection, prosthesis fitting rate, and mobility with a prosthetic limb. Statistical analysis by Chi-square and t-test was used to compare two groups as regard quantitative variables in parametric data ($SD < 25\%$ mean).

Results: Regarding the early post-operative outcomes in terms of death in the 30 days post-operative period, incidence of cardiac events within 30 days post-operatively, primary healing after 7 days, wound discharge after 7 days, incidence of minor edge necrosis after 7 days, major flap necrosis after 7 days, revision of stump & post-operative stay period. Comparing the 2 tested groups using the Chi square showed no significant statistical differences between both of them. Regarding the late outcome results including the survival within 6 months, among the 25 patients of group 1, 20 patients survived till 6 months postoperatively (80% survival rate), while among the 25 patients of group 2, 18 patients survived till 6 months postoperatively (72% survival rate). Regarding prosthesis fitted within 6 months, among the 20 patients of group 1, 5 patients used the below knee prosthesis (25%), while among the 18 patients in group 2, 3 patients used the prosthesis (18.18%). Regarding the mobility status of patients with 6 months post-operative: among the 20 patients of group 1, among 20 patients of group 1, 3 patients were immobile (16.67%), 12 patients were dependent (60%), and 5 patients were independent (25%). While among the 18 patients of group 2: 2 patients were immobile (11.11%), 13 patients were dependent (72.22%) and 3 patients were independent (16.67%). By comparing the two groups regarding the mobility status within 6 months post-operative, there was no significant statistical difference using Chi square.

Conclusion: The skew flap technique is considered the routine procedure for below knee amputation in many centers around the world. We conclude that the skew flap is just as effective as the long posterior flap. Skew flap is especially useful when below knee amputation is indicated and the posterior skin is inadequate to construct a long posterior flap.

Key words: Trans-tibial amputation, skew-flap, long posterior flap.

Introduction:

Amputation of a damaged limb is one of the oldest and, arguably, most effective surgical procedures. A properly performed amputation holds the promise of pain relief for patients with advanced ischemia & control of infection in the setting of extremity sepsis. Unfortunately, vascular surgeons often regard amputation as the terminal battle in the war against atherosclerosis and an admission of personal failure.¹ Transtibial (below-knee) amputation is indicated when gangrene or infection precludes a more distal procedure and for intractable ischemic rest pain that cannot be corrected by lower extremity revascularization. Below-knee amputation (BK) is the most proximal amputation that is still associated with a good rehabilitation procedure. All variations of the transtibial amputation are designed to provide adequate distal end padding and produce a cylindrical stump that can be readily cast for a procedure.² The surgeon should aim to provide adequate tissue cover over the end of the transected tibia and avoid placing of the suture lines at sites subject to pressure from a below-knee prosthesis.³ The success of the long posterior flap in obtaining sound healing at below-knee level is widely recognized in patients with ischaemic disease, and since this method was introduced in 1967 by Burgess and Romano, the number of patients with healing below-knee amputations in ischaemic disease has dramatically increased, and with improved methods of level selection this proportion may increase further.⁴ However, the long posterior flap below-knee stump has several problems. The stump may be wide in the transverse diameter causing difficulties in delay in limb fitting; the scar crossing the tibia may break down with prosthetic use, and to avoid these problems we undertook a review of the basic design of the below knee amputation stump to utilize the best available blood supply and avoid these difficulties. Sagittal flaps result in the anterior part of the incision, and therefore the scar overlying the anterior crest of the tibia is exposed to pressure from patellar tendon bearing socket. If the line of the incision is rotated by 150, the scar is brought 2.0 cm

lateral to the crest of the bone, which results in skewed flaps and the scar is removed from the point of high pressure.⁵ The aim of this study is to compare the skew flap and the long posterior flap below-knee amputation in patients with peripheral vascular disease in terms of stump healing, wound infection, reamputation rate, and mobility with a prosthetic limb as outcome measures.

Patients and methods:

This comparative randomized prospective study was conducted at Ain Shams University hospitals and two tertiary referral hospitals in Saudi Arabia in the period from September 2010 to December 2012. Fifty patients with chronic atherosclerotic occlusive disease of the lower extremity and critical ischemia (intractable rest pain, ulcer or gangrene) for whom no other treatment options remained and in whom below-knee amputation was indicated were included in the study. Patients were randomized into two groups. Group 1 (n=25) underwent skew flap BKA; Group 2 (n=25) underwent long posterior flap BKA. All patients signed an informative written consent. The preoperative information obtained for each group includes: age, sex, mean age, smoking, diabetes, CBC, renal and liver profiles, cardiac, renal, neurologic and hepatic comorbidity, indications for amputation as rest pain, necrosis or both, Previous surgical reconstruction (ipsilateral arterial reconstruction, ipsilateral angioplasty, ipsilateral foot amputation and contralateral major amputation).

The two groups will be compared in terms of the above mentioned pre-operative information.

The early outcome for each group includes:

- 1) Death in the early post-operative period (within 30 days).
- 2) Cardiac and other major events (e.g. Stroke).
- 3) State of healing at 1 week: a) Primary healing. b) Wound discharge. c) Minor wound edge necrosis. d) Major flap necrosis leading to revision to above-knee amputation.
- 4) Revision of amputation stump: a) No revision. b) Revision at same level.

c) Revision to higher level.

5) The average length of post-operative stay.

The early outcome for each group will be compared in terms of the above mentioned data.

Late outcome at 6 months will be assessed in terms of:

- 1) Limb fitted with prosthesis at 6 months.
- 2) Mobility at 6 months (immobile, dependent or independent).

Late outcome of each group will be compared. Statistical analysis by Chi-square and t-test was used to compare two groups as regard quantitative variables in parametric data ($SD < 25\%$ mean).

Results:

This comparative randomized prospective study was conducted at Ain Shams University Hospital, Almoosa Specialized Hospital and Tabouk Military Hospital in KSA in the period from September 2010 to December 2012. Fifty patients with chronic atherosclerotic occlusive disease of the lower extremity and critical ischemia (intractable rest pain, ulcer or gangrene) for whom no other treatment options remained and in whom below-knee amputation was indicated were included in the study. Patients were randomized into two groups. Group 1 (n=25) underwent Skew Flap BKA; Group 2 (n=25) underwent long posterior flap BKA. All patients signed an informative written consent. **Table (1)** demonstrates patients' demographic data together with risk factors, comorbid conditions, indications for amputation and previous surgical operations. Regarding all the pre-operative factors including the age, sex, smoking, diabetes, pre-operative morbidities, previous surgical reconstruction and indication for the amputation: comparing the 2 tested groups using the Chi square showed no significant statistical differences between both of them.

Regarding the early post-operative outcomes in terms of death in the 30 days post-operative period, incidence of cardiac events within 30 days post-operatively, primary healing after 7 days, wound discharge

after 7 days, incidence of minor edge necrosis after 7 days, major flap necrosis after 7 days, revision of stump & post-operative stay period are shown in **Table (2)**. Comparing the 2 tested groups using the Chi square showed no significant statistical differences between both of them **Table (2)**.

Regarding the late outcome results including the survival within 6 months, among the 25 patients of group 1, 20 patients survived till 6 months postoperatively (80% survival rate), while among the 25 patients of group 2, 18 patients survived till 6 months postoperatively (72% survival rate). Regarding prosthesis fitted within 6 months, among the 20 patients of group 1, 5 patients used the below knee prosthesis (25%), while among the 18 patients in group 2, 3 patients used the prosthesis (18.18%) **Table (3)**.

Regarding the mobility status of patients with 6 months post-operative: among the 20 patients of group 1, among 20 patients of group 1, 3 patients were immobile (16.67%), 12 patients were dependent (60%), and 5 patients were independent (25%). While among the 18 patients of group 2: 2 patients were immobile (11.11%), 13 patients were dependent (72.22%) and 3 patients were independent (16.67%). By comparing the two groups regarding the mobility status within 6 months post-operative, there was no significant statistical difference using Chi square. **Table (4)**.

Discussion:

The success of the long posterior flap in obtaining sound healing at below-knee level is widely recognized in patients with ischemic disease, and since this method was introduced in 1967 by Burgess and Romano, the number of patients with healing below-knee amputations in ischemic disease has dramatically increased, and with improved methods of level selection this proportion may increase further.⁴ However, the long posterior flap below-knee stump has several problems. The stump may be wide in the transverse diameter causing difficulties in delay in limb fitting; the scar crossing the tibia may break down with prosthetic

use, and to avoid these problems Robinson undertook a review of the basic design of the below knee amputation stump to utilize the best available blood supply and avoid these difficulties. Very little separation of the skin from the muscle flap occurs when this is performed, and no significant perforating arteries are divided.⁵ Spence and McCollum, using thermography and oximetry, suggest that the least good blood supply to the skin at this level is on the lateral aspect of the stump. If the flap is based on the distribution of the sural nerve artery and the saphenous nerve artery, then a posterolateral flap and an anteromedial flap results. If any deficiency is revealed in the lateral skin, this flap can be shortened in relation to the medial flap. The skew flaps appear to make best use of the inflow from these two cutaneous arteries.⁵ In our study we compared between the two types of below knee amputations: the skew flap BKA described by Robinson and long posterior flap BKA as described by Burgess and Romano. We compared the early outcome between the two groups in terms of: death during the early post-operative period (within 30 days), the cardiac and other major events post-operatively, state of healing at 1 week post-operatively, the need of the revision of the amputation stump and the average length of the post-operative stay. We compared the late outcome at 6 months between the two groups in terms of: limb fitted with prosthesis at 6 months, mobility status during the 6 months follow up. Out of fifty patients recruited in our study, only 38 patients were available at the end of the study due to death of 12 patients. 5 patients died in the early postoperative period (30 days), and further 7 died within 6 months postoperatively. The two groups were well matched in respect to age, sex, smoking, diabetes, co-morbidities, indication for the amputation and the previous surgical reconstruction. We found only 2 studies comparing the outcome of both long posterior flap and skew flap below knee amputation. The first one was a retrospective review of major lower limb amputations in Derby between October 1979 and October 1986, taking April 1983 as the dividing point

for the two 3 and half year periods as it was then that the skew flap (SF) below-knee amputation was adopted.⁷ In the first period 211 amputations were performed, and in the second 142. The indication for surgery was irrevocable ischaemia in the majority, diabetic gangrene being responsible for the remainder. There was no significant difference between the long posterior flap (LPF) and the skew flap (SF) groups with respect to the incidence of diabetic gangrene. The case notes were analyzed for patient's age, previous vascular surgery, coexisting medical conditions, indications for surgery, operation performed and operative mortality. Operative mortality is defined as death occurring within 30 days of the most recent operation.⁸ A commonly employed method of comparing the results of amputations is to look at the length of time spent in hospital in each of the groups. In that study a random sample of 75 cases was examined for correlation between length of hospital stay and time to full healing.^{7,8} The second study was a multicenter trial in which surgeons in 11 centers randomized 191 patients with end-stage occlusive vascular disease to two different methods of stump construction. The skew flap technique was performed in 98 and the long posterior flap was performed in 93. The two groups were well matched in respect to age, sex, smoking, diabetes, and indications for amputation. Early outcome was compared in terms of 30-day mortality rate; the state of the wound at 1 week; the need for surgical revision at the same level, and revision to a higher level. Follow-up information at 6 months was available from records or by mailed questionnaire in 188 (98%) at 6 months, 20 died during that interval.²

In our study, among the 25 patients of group 1 : 2 patients (8%) died in the 30 days post-operative period, while among the 25 patients of group 2 : 3 (12%) patients died. These differences were not statistically significant. Our results were comparable to the results of Harrison et al. There was no significant difference between the operative mortality in the long posterior flap group (4/21 patients) and the skew flap group (3/38 patients)

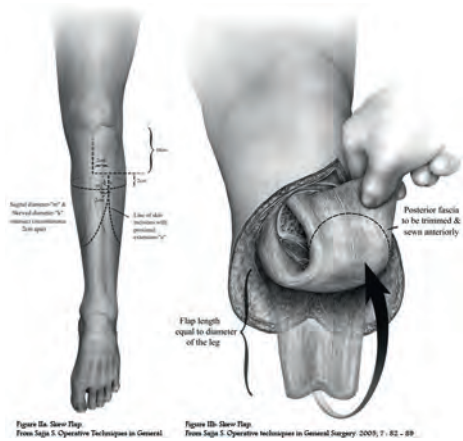


Figure (1): Illustrative diagram of the technique of skew flap below knee amputation.⁶

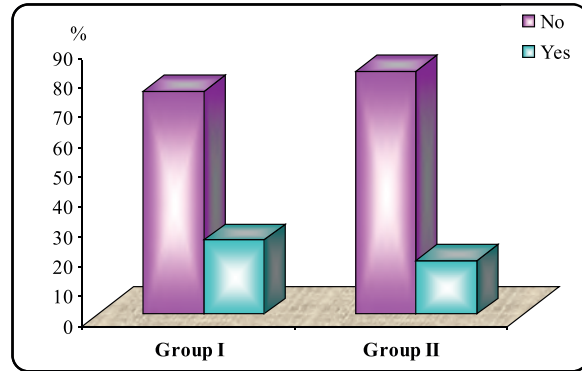


Figure (2): Descriptive statistics of prosthesis fitted within 6 months.

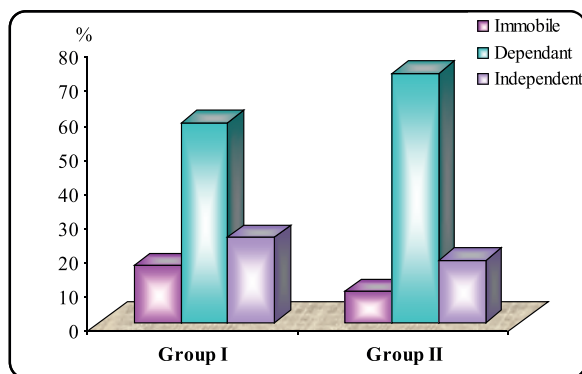


Figure (3): Descriptive statistics of mobility status within 6 months.

during the period 1983-86.⁷ Our results were also comparable to those of Ruckley et al. He reported that death in the early postoperative period (within 30 days) occurred in 27 patients: 11 (11%) skew flap and 16 (17%) long posterior flap patients. These differences were not statistically significant.²

In our study, among the 25 patients of group 1: 13 patients had primary healing within 7 days post-operative (52 %) while among the 25 patients of group 2:11 patients had primary healing (44%). These differences were not statistically significant. Among the 25 patients of group 1:12 patients had wound discharge after 7 days post-operative (48%). while among the 25 patients of group 2: 14 patients had wound discharge (56%). These differences were not statistically significant. Among the 25 patients of group 1: 5 patients had minor edge necrosis (20%). while among the 25 patients of group 2: 7 patients had minor edge necrosis (28%). These differences

were not statistically significant. Among the 25 patients of group 1 : 2 patients had major flap necrosis (8%). while among the 25 patients of group 2:3 patients had major flap necrosis (12%). These differences were not statistically significant.

Regarding revision of the stump: among the 25 patients of group 1 : 2 patients had revision at the same level (8%) and 1 patient had revision at a higher level (4%), while among the 25 patients of group 2 : 1 patient had revision at a same level (4%) and 1 patient had revision at higher level (4%). These differences were not statistically significant.

Our results were also comparable to those of Ruckley et al. In respect to primary healing at 1 week, the two groups were identical at 60%. Wound discharge or minor wound edge necrosis was observed in 21 (21%) of the skew flap and 26 (24%) of the Burgess stumps. Major failure of healing led to revision to the above-knee level in 10 (10%) after skew and

Table 1: Patients' demographic data, risk factors, comorbid conditions, indications for amputation and previous surgical operations.

	Skewflap amputation	Long posterior flap amputation	Chi square (X ² /P value)
Males	17 males (68%)	15 males (60%)	0.556/0.456 for gender
Females	8 females (32%)	10 females (40%)	
Mean age (range)	Mean age 64.133 (SD 8.02): range from 48 to 80	Mean age 66.333 (SD 6.449): range from 57 to 82	0.416
Smoking status			0.133/0.715 for smoking
Never	12 (48%)	13 (52%)	
Former Current	5 (20%) 8 (32%)	4 (16%) 8 (32%)	
Diabetes	20 (80%)	18 (72%)	0.186/0.666
Cardiac comorbidities	8 (32%)	8 (32%)	0.000/1.000
Renal comorbidities	2 (8%)	2 (8%)	0.000/1.000
Neurological comorbidities	2 (8%)	1 (4%)	1.034/0.309
Hepatic comorbidities	3 (12%)	2 (8%)	0.370/0.543
Indication for operation			0.202/0.904 for indication of amputation
Necrosis			
Rest pain	15 (60%)	13 (52%)	
Both	5 (20%) 5 (20%)	5 (20%) 7 (28%)	
Previous surgical operation			1.396/0.706
No	12 (48%)	17 (68%)	
Contralateral BKA	2 (8%)	2 (8%)	
Tibial angioplasty	7 (28%)	3 (12%)	
Ipsilateral minor amputation	5 (20%)	3 (12%)	

in 7 (8%) after Burgess operation.² Harrison et al., stated that time to full stump healing was significantly shorter in the skew flap group compared to the long posterior flap amputations ($P = 0.001$), which could not be concluded from our study.⁷

Regarding stump failure requiring conversion to an above knee amputation, our results were comparable to results reported by Harrison et al. Stump revision requiring above knee amputation occurred in only 5.3 per cent of skew flap amputations compared to 11.3 per cent in the Burgess long posterior flap amputations, although this just failed to reach statistical significance. Harrison

stated that his experience shows that the rate of primary healing is significantly better following a skew flap amputation than after a Burgess long posterior flap below-knee amputation, allowing a higher proportion of below-knee amputations to be performed with a trend toward fewer stump failures.⁷ This conclusion by Harrison et al., was not supported by our results nor the results reported by Ruckley et al., which showed no statistically significant differences between the two groups regarding stump failure and the need of revision using above knee amputation. Regarding the average length of the post-operative stay: for group 1 the

Table 2: Early outcome.

	Skewflap amputation	Long posterior flap amputation	Chi square (X2/P value)
Wound healing (after 7 days)			
Primary healing	13 (52%)	11 (44%)	0.133/0.715
Wound exudate	12 (48%)	14 (56%)	0.133/0.715
Minor edge necrosis	5 (20%)	7 (28%)	0.186/0.666
Major flap necrosis	2 (8%)	3 (12%)	0.370/0.543
Cardiac events within 30 days postop.	2 (8%)	3 (12%)	0.370/0.543
Early death (30 days postop.)	2 (8%)	3 (12%)	0.370/0.543
Revision of amputation stump			
No revision	22 (88%)	23 (92%)	1.045/0.472
Revision at the same level	2 (8%)	1 (4%)	
Revision at higher level	1 (4%)	1 (4%)	
Post-operative stay period (days)	Mean 6.467 (SD 4.912) : range from 2.0 to 18.0	Mean 7.000 (SD 4.276) : range from 2.0 to 16.0	-0.317/0.753

Table (3): Descriptive statistics of prosthesis fitted within 6 months.

Prosthesis	Groups					
	Group I		Group II		Total	
	N	%	N	%	N	%
No	14	70.00	15	83	29	76.32
Yes	6	25.00	3	18.18	9	23.69
Total	20	100.0	18	100.0	38	100.0
Chi-square	X2	0.157				
	P-value	0.692				

Table (4): Descriptive statistics of mobility status within 6 months.

Mobility	Groups					
	Group I		Group II		Total	
	N	%	N	%	N	%
Immobile	3	16.67	2	11.11	5	13.16
Dependent	12	60	13	72.22	25	65.79
Independent	5	25	3	16.67	8	21.05
Total	20	100.00	18	100.00	38	100.00
Chi-square	X2	0.558				
	P-value	0.757				

average period was 6.46 days (SD 4.9) (range from 2 to 18 days), while for group 2 the average period was 7 days (SD 4.27) (range from 2 to 16 days). These differences were

not statistically significant.^{2,7} Ruckley stated the average length of postoperative stay in the surgical wards was 36 days after skew and 42 after Burgess operation. These differences

were not statistically significant.²

Among the 25 patients of group 1 : 20 patients survived till 6 months postoperative (6 months survival rate 80%), while among the 25 patients of group 2: 11 patients survived (6 months survival rate 73.33 %). These differences were not statistically significant. Our results were also comparable to those of Ruckley et al. He stated that 20 patients had died (9 skew and 11 Burgess) during the 6 months follow-up period.² In our study, among the 20 patients of group 1 : 5 patients used the below knee prosthesis (25%), while among the 18 patients of group 2 : 3 patients used the prosthesis (18.18%). These differences were not statistically significant.

Regarding the mobility status of the patients within 6 months post-operative: among the 20 patients of group 1 : 3 patients were immobile (16.67%), 12 patients were dependents (60%) and 5 patients were independents (25%). While among the 18 patients of group 2 : 2 patients were immobile (11.11%), 13 patients were dependents (72.22%) and 3 patients were independents (16.67%).^{2,9} By comparing the two groups regarding the mobility status within 6 months post-operative, there was no significant statistical difference using Chi square.

Our results were different from the results reported by Ruckley et al., who stated that 64 (84%) of the skew and 50 (77%) of the Burgess patients had been fitted with prostheses ($X^2 = 0.78, p = 0.38$) and 59 (78%) and 46 (71%), respectively were walking with or without aid. These differences were not statistically significant. This difference was caused due to the high cost of the prosthesis in Egypt which could not be afforded by the majority of our patients and lack of availability of prosthesis in Saudi Arabia.

Among the 25 patients of group 1, there were 2 patients with infection extending on the posterior aspect of the foreleg above the ankle joint, to a level that makes long posterior flap BKA not applicable, so skew flap amputation was performed. One of these two patients had primary healing within the 7 days postoperatively while the other had wound discharge and minor edge necrosis

within the 7 days postoperatively and healing was delayed till the 19th day postoperatively. This was mentioned in Rutherford's vascular surgery 7th edition: the skew technique may be of particular benefit when there is inadequate skin to create a conventional long posterior flap.¹⁰ Our study revealed no significant statistical differences between the two groups regarding both the early and late outcomes. The skew flap technique is considered the routine procedure for below knee amputation in many centers around the world.

Conclusion:

The skew flap technique is considered the routine procedure for below knee amputation in many centers around the world. We conclude that the skew flap is just as effective as the long posterior flap. Skew flap is especially useful when below knee amputation is indicated and the posterior skin is inadequate to construct a long posterior flap.

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