Skew-flap below-knee amputation

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The success of the long posterior flap in obtaining sound healing at below-knee level is widely recognised 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 (1). 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 utilise the best available blood supply and avoid these difficulties. Haertsch (2) studied the skin blood supply by post-mortem injection studies and McCollum et al. (3) indicated that the dominant vascular supply to the skin at this level is by the saphenous nerve artery and the sural nerve artery. Previously the posterior skin flap had been thought to receive the best blood supply from the gastrocnemius muscle surface by perforating arteries. Dellon and Morgan (4) drew attention to this, although Towne and Condon (5) had previously recognised the role of the sural nerve artery. Fulford (6) reported that the skin over the upper part of the anterior tibial compartment had particularly unsatisfactory blood supply, basing this observation on arteriographic studies. The long posterior flap was first illustrated by Hiester in 1739, while the sagittal flap attributed to Monsieur Lenoer and also myocutaneous sagittal flaps ascribed to Monsieur Sedellot are illustrated by Bougery and Jacob (1835) in the Atlas of Operative Surgery. However, more recent authors, Tracy (7), Alter et al. (8), Termansen in 1977, and Persson in 1974, reported the use of sagittal flaps for below-knee amputation. Persson (9) used myocutaneous flaps cut in one piece to provide a degree of myoplastic function. Bek (10) reported a further series and, more recently, Yamanaha and Kwong reported a similar technique in 1985.

Sagittal flaps result in the anterior part of the incision, and therefore the scar overlying the anterior crest of the tibia where it is exposed to pressure from patellar tendon bearing socket. If the line of the incision is rotated by 15°, the scar is brought 2.0 cm lateral to the crest of the bone, which results in skewed flaps and the scar removed from the point of high pressure. Unfortunately, myocutaneous flaps cannot be cut in this line and we therefore suggested a myoplasty based on the long posterior flap operation, forming the gastrocnemius soleus muscle into a long posterior myoplastic flap within the skewed skin flaps. By folding the muscle over the ends of the tibia, the medullary cavity is closed, enhancing the blood supply of the transected bone (11). Very little separation of the skin from the muscle flap occurs when this is performed, and no significant perforating arteries are divided.

Spence and McCallum (3), 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, but if thermoscanning or dye injection techniques are available and the optimum pattern of skin perfusion in any one patient could be determined prior to surgery, then the flaps could be varied to make best use of the local skin blood flow, but without these studies the skewed sagittal skin flap appears to correlate well with the present information about the distribution of skin blood flow.

Method

Before surgery, the perineum is isolated with a cotton wool pad. The skin is prepared with povidone solution and wrapped in sterile towels. A rectal swab is taken to identify Clostridia carriers, but all patients are treated with metronidazole and cefotaxime prophylactically. The operation is conducted under regional or general anaesthesia. On the operating table, the patient is placed

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supine, taking care to protect the opposite leg from pressure. In diabetic patients without large vessel disease, a tourniquet is put in place but not inflated. The skin flaps are carefully marked on the skin. Bone section is selected to 10–15 cm below the tibial plateau. The minimum stump length should allow 3 cm of the stump to protrude below the flexor tendons when the knee is at 90° of flexion. The line of bone section is marked around the limb and a point is drawn on this line 2 cm lateral to the subcutaneous crest of the tibia, and this marks the point of intersection of the scar anteriorly. The measuring tape is halved and used to locate the posterior junction of the flaps. The tape is then quartered to indicate the midpoint of each flap and the quarter circumference is used to indicate the limit of the semicircular flap. A 2 cm proximal extension of the scar is made anteriorly to allow better access to the anterior tibial compartment. The leg is prepared with a further application of povidone solution and draped to isolate the foot and thigh from the perineum. The skin flaps are cut along the previously marked lines. The skin and superficial fat are divided to the level of the deep fascia. The long and short saphenous veins are identified and ligated, preserving their related artery and avoiding the saphenous and sural nerves which are divided under tension. The anterior scar is retracted to expose the anterior tibial compartment where the muscles are divided transversely until the anterior tibial artery and vein are exposed. These are secured with artery forceps and can be divided, being ligated with fine catgut or Vicryl®. The anterior tibial nerve is divided under traction. The peroneal muscles are divided and the musculocutaneous nerve cut under traction. The interosseous membrane is divided at the same level and the peristemeum elevated from the tibia and fibula. If a cantilever blade power saw is available this can be used to cut a smooth curve on the tibia, provided overheating is avoided by adequate irrigation. Bone division is easiest if the fibula is divided first 2 cm proximal to the line of tibial bone section. The distal tibia is stabilised with a bone hook and traction on this exposes the tibialis posterior. This is cut transversely revealing the peroneal and posterior tibial neurovascular bundles which are temporarily clamped. The gastrocnemius/soleus mass is separated from the amputation specimen until the gastrocnemius can be transected well below the line of bone section and the specimen can be removed. The posterior muscle flap can then be fashioned and trimmed with a large scalpel or amputation knife to produce a uniform taper to its distal end, and also to remove muscle bulk from the medial and lateral aspect of the flap, so that when it is folded over the stump will not be unduly wide (Fig. 1). Several soleal venous sinuses and muscle branches will be cut and these usually require under-running with a catgut or Vicryl ligature to obtain haemostasis. At this point the temporarily clamped peroneal and posterior tibial neurovascular bundles can be dissected. The arteries and veins can be re-clamped, allowing the posterior tibial nerve to be separated and divided under tension. The major vessels are ligated with Vicryl or catgut and haemostasis completed with diathermy. A suction drain is now placed in relation to the bone ends and the myoplasty effected by folding the muscle flap forward and trimming it to match the anterior tibial periosteum and the anterior tibial fascia. At this stage the bone ends require considerable attention to produce a smooth, atraumatic surface. Both cut ends are smoothed with a fine bone rasp and the surface then smoothed with a bone file. The tibia should be well rounded without any angular prominence and the rounding should include the posterior aspect of the bone to bring the contour as near hemispherical as possible. The fibula also requires attention to remove the angular margins. Any bone fragments that might release calcium ions are carefully washed away and the myoplasty constructed by suturing the gastrocnemius soleus mass anteriorly with 0 catgut or Vicryl. The skin falls into place with a minor degree of redundancy and can be sutured without any tension. Fine nylon sutures are preferred as the stump will be stressed when the patient uses the postoperative pneumatic walking aid, but Steri-strips® are placed between each suture. Very little dressing is applied. Lightly fluffed gauze with a covering of a loose spiral crêpe bandage is applied for 48 h. At this time the drain can be removed and its contents cultured. Antibiotics are continued for 3 days and, in favourable cases, the patient can stand using the pneumatic walking aid between the 2nd and 5th postoperative day. The pneumatic walking aid is not worn for more than 1 h at a time and the inflation pressure is limited to 40 mmHg. The use of the walking aid is always supervised by the physiotherapist. The patient is able to walk between parallel bars, but may later progress to a walking frame, tetrapods or walking sticks.

The cast for the first resin socket can be taken as soon as any oedema and swelling has resolved. This has been as early as the 7th postoperative day, but in vascular patients it is usually delayed until the 21st day, at which
time the sutures are removed. The patellar tendon bearing socket can be worn as soon as it is manufactured and without any adverse factor the patient should be able to walk independently and leave hospital between 4 and 5 weeks after the operation.

The selection of the level for a below-knee amputation is crucial for wound healing. Transcutaneous oximetry is a very satisfactory method of level selection. A transcutaneous oximetry value of less than 40 mmHg is unlikely to be accompanied by wound healing at this level without an unacceptable rate of secondary surgery or reamputation. Below-knee amputations have healed at lower values. The ankle systolic pressure measurement has also been utilised and the same value of 40 mmHg represents the minimum pressure for an acceptable primary healing rate, although successful below-knee amputations have been obtained in patients without any recordable ankle systolic pressure. A better indication is claimed for the popliteal systolic pressure, which should not be less than 70 mmHg. There are problems with all selection techniques and a composite of all the available information is usually required to make the correct choice. The part of the leg causing rest pain must be eliminated by the amputation. The operation must be conducted through warm, well perfused, normally coloured skin and soft tissue. Below-knee amputation is avoided for patients who will not walk. These patients sitting in a wheelchair will allow the stump to flex and become oedematous, with the likely consequence of an ulcer at the stump end. Similarly, an uncooperative patient who cannot voluntarily extend the knee will not benefit from a below-knee amputation. A patient who already has an established fixed flexion deformity of the knee is unlikely to revert with even the most intensive physiotherapy. However, 45° of flexion may be incorporated in the design of the PTB prosthesis and still obtain reasonable function, but the more severe flexion deformity is a contraindication to the below-knee level of amputation.

Results

A total of 131 skew flap, below-knee amputations have been performed in 122 patients. Of these, 109 had peripheral vascular disease and 54 were diabetic. The average age of patients with atheroma disease was 70 years and for those with diabetes 66 years. The hospital mortality was 4.5%, and 95% were rehabilitated to independent walking. Wound healing was delayed in seven patients (5.3%), reamputation was required in nine patients (6.8%) and a retrimming procedure in a further nine (6.8%), an overall incidence of secondary surgery of 13.7%. The patients in this series were treated at the Roehampton Limb Surgery Unit and were not discharged until full independent function was achieved. The patients were not discharged home until a home visit had established that the patient was fully independent in their own environment, and delays in discharge frequently resulted from problems associated with modification to the home and rehousing. As a result of these factors, the time to discharge does not reflect the physical ability of the patients to leave hospital. In those patients who have primary wound healing, the prosthesis was supplied 24 days after the operation and discharge home could be achieved in 32 days.

Discussion

The skew-flap amputation is easy to learn and produces a reproducibly satisfactory shape of the stump at the conclusion of the operation. A parallel-sided hemispherical-ended stump can be obtained by an inexperienced surgeon following the technique. The hazards of constricting bandages are avoided and early ambulation in the pneumatic walking aid is possible from the 5th postoperative day. The incidence of serious wound breakdown and secondary surgery is comparable with most published series of below-knee amputation (12). Retrim procedures, when necessary, have been easy to achieve, retaining the basic design of the stump. There has not been any trend in the part of the stump that may break down to suggest any fault in the design. The patients have used a pneumatic walking aid without difficulty and the provision of a PTB prosthesis has been possible in the early postoperative period.

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