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A reappraisal of a modified through-knee amputation in patients with peripheral vascular disease

David L. Cull, M.D.*, Spence M. Taylor, M.D., Steven E. Hamontree, C.P.O., Eugene M. Langan, III, M.D., Bruce A. Snyder, M.D., Timothy M. Sullivan, M.D., Jerry R. Youkey, M.D.

Vascular Surgery Service, Department of Surgical Education, Greenville Hospital System, 701 Grove Rd., Greenville, SC 29605, USA

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Abstract

Background: Through-knee amputation provides a longer lever arm and improved muscle control of the limb compared with above-knee amputation. Through-knee amputation also allows use of a total end-bearing prosthesis, which avoids the ischial pressure and suspension belts required of the above-knee amputation prosthesis. Several reports in the European literature tout the superiority of the through-knee amputation over the above-knee amputation in the patient with vascular disease. Through-knee amputation has received little attention in the United States, however, owing to the belief that the long flaps necessary to close a standard through-knee amputation are associated with an unacceptable rate of wound problems and offer no functional ambulatory advantage to above-knee amputation. We reviewed our experience with a modified technique of through-knee amputation in a group of patients with severe lower extremity ischemia who were not candidates for below-knee amputation to determine the incidence of wound complications and their functional outcome.

Methods: Since 1996, 12 patients with severe lower extremity arterial insufficiency have undergone through-knee amputation utilizing a technique designed to limit flap length and facilitate the fit of a suction prosthesis. Two patients died of myocardial infarction in the immediate postoperative period and were excluded from the study. In the remaining 10 patients (1 man, 9 women; mean age 63 years (range 40 to 86), the below-knee amputation level was precluded because of gangrene or nonhealing wounds of the mid leg in 5 patients, failure of a previous below-knee amputation attempt in 4 patients, and severe ischemia that would compromise below-knee amputation healing in 1 patient. Nine patients had at least one failed vascular reconstruction procedure.

Results: Mean follow-up is 25 months (range 6 to 41). Six (60%) patients had primary healing of their amputations. Two (20%) patients had delayed healing (6 weeks and 8 weeks). Two (20%) patients developed wound infections, which required amputation revision to the above-knee level. Seven (70%) patients were fitted with a suction socket prosthesis and are fully ambulatory. One patient healed but has not ambulated because of ischemia and subsequent ulceration of the contralateral limb.

Conclusions: These data show that through-knee amputation is associated with an acceptable primary healing rate (80%) and satisfactory functional outcomes (70% ambulation) in a high-risk vascular population. The functional advantages of through-knee amputation over above-knee amputation make it the preferred alternative for patients with vascular disease.

Keywords: Through-knee amputation; Knee disarticulation technique; Peripheral vascular disease; Modified technique

More than 60,000 major limb amputations are performed in the United States annually. The majority of these are performed for consequences of peripheral vascular disease. The through-knee amputation was first recorded in the Western scientific literature in 1824. Early proponents of the procedure cited simplicity and speed of the operation and reduced mortality related to infection as advantages over the above-knee amputation. These advantages of through-knee amputation were rendered obsolete with the advent of modern anesthesia and aseptic technique. The above-knee amputation and below-knee amputation became the standard amputation levels and the through-knee amputation was largely abandoned during World War II because the stump was unsightly and difficult to fit with a prosthesis [1].

Over the past 4 decades, major advances in prosthetic technology and design now provide a prosthesis for the

* Corresponding author. Tel.: +1-864-455-5795; fax: +1-864-455-7082.

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through-knee amputation with significant advantages over the above-knee amputation prosthesis. Several studies have shown reduced metabolic cost of walking and superior rehabilitation outcomes with through-knee amputation compared with above-knee amputation [2–6].

Despite these advantages, many surgeons, including advocates of the through-knee amputation, have considered the procedure contraindicated in the dysvascular patient. This stems from the belief that the long flaps necessary to close the through-knee amputation over the femoral condyles are associated with unacceptable wound complications in the patient with vascular disease [7–9].

Since 1996, we have performed through-knee amputation on a select group of patients with severe peripheral vascular disease who were not candidates for below-knee amputation. A modified through-knee amputation technique involving resection of the patella and shaving the femoral condyles was utilized to limit the length of the amputation flaps. This study reviews our experience in these patients with regard to wound healing rates and the ultimate level of rehabilitation achieved.

Patients and methods

Between March 1996 and February 1999 the Vascular Surgery Service at Greenville Memorial Hospital performed through-knee amputation on 12 patients with severe lower extremity arterial insufficiency. Patient data were extracted from a vascular database, review of hospital and office records, and patient interview.

The level of amputation required was determined by the clinical judgment of the operating surgeon after assessment of the extremity skin color, temperature, location of leg wounds, and pulse status of the extremity. Patients with severe arterial insufficiency were considered for through-knee amputation if they met two criteria. First, the patient had to have the potential to ambulate on a prosthetic limb. Second, the patient could not be considered a candidate for a below-knee amputation. A patient's rehabilitation potential was determined by a preoperative evaluation involving interviews with the patient and family, which focused on the patient's activity level in the days and weeks prior to surgery and an assessment by a prosthetist. A physiatrist was consulted in questionable cases. In situations where a traditional below-knee amputation could not be performed owing to severe ischemia or location of leg wounds, a short below-knee amputation was performed in preference to a through-knee amputation.

Operative technique

Under epidural anesthesia, the patient was placed in the supine position. A standard fishmouth incision with equal anterior and posterior skin flaps was used. The anterior flap extended to the tibial tuberosity (Fig. 1). The patellar tendon

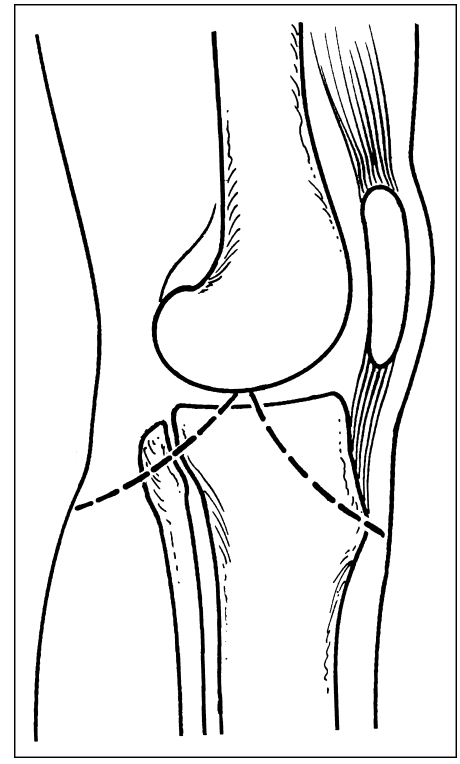

Fig. 1. Equal anterior and posterior skin flaps are used. The apex of the skin flap is at the tibial tubercle.

was detached from the tibia. The skin and deep fascia were dissected off the capsular structures of the knee. The knee capsule was incised circumferentially and the cruciate ligaments divided. The popliteal artery and vein were suture ligated. The common peroneal and tibial nerves were transected sharply under tension. The patella was excised from its tendon with particular care taken to avoid injury to the overlying skin and subcutaneous tissue. A wide osteotome was used to remove the protruding lateral, medial, distal, and posterior condylar surfaces (Fig. 2). Bone edges were smoothed with a rasp. The fascia and skin were closed separately (Fig. 3).

Sutures were generally removed 4 weeks after surgery, and a compression sock was applied to the stump. Patients were examined at weekly intervals and residual limb measurements were obtained. Prosthetic fitting and fabrication was initiated when the stump was well healed and not tender, the residual limb volume stabilized, and the patient was able to stand and bear weight on the contralateral limb. These goals were usually achieved between 8 and 12 weeks after surgery. Patients were fit with a total contact, distal weight bearing, suction socket prosthesis with a four bar linkage polycentric prosthetic knee.

Results

Two of the 12 patients who underwent through-knee amputation died of myocardial infarction in the immediate

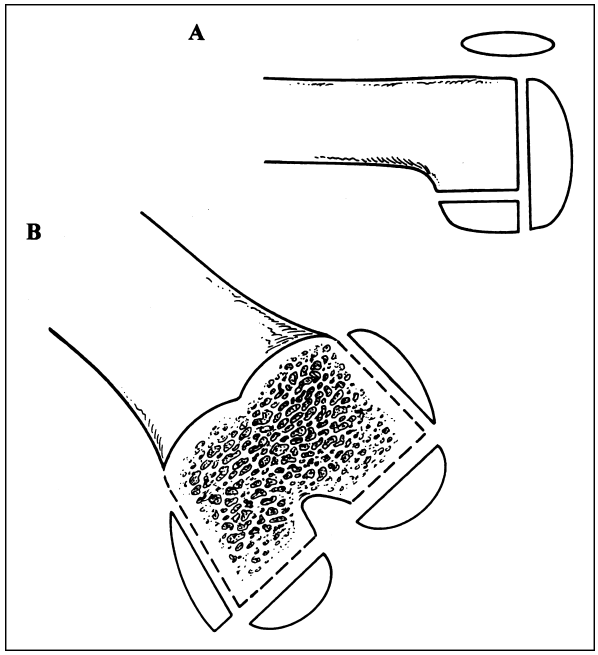

Fig. 2. The cone-shaped stump is achieved by shaving the condyles. **A.** The distal and posterior surfaces of the femoral condyles are removed. The patella is excised. **B.** The lateral condyles are removed.

postoperative period and were excluded from the study. The mean patient age was 63 years with a range between 40 and 86 years. Nine patients were women (90%), 3 (30%) had significant coronary artery disease, 8 (80%) were hypertensive, 4 (40%) had diabetes mellitus, and 5 (50%) were smokers.

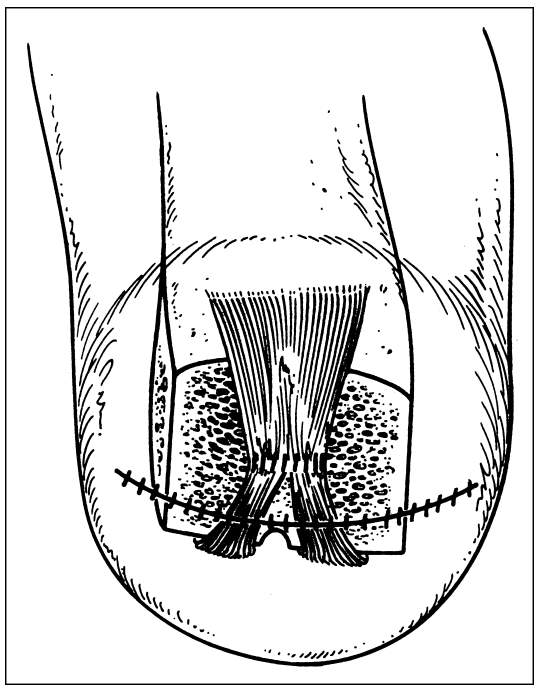

Fig. 3. The patellar tendon is sutured to the hamstrings. The anterior and posterior fascia and skin are closed separately.

Four patients (40%) had a failed below-knee amputation. The etiology of limb ischemia was chronic occlusive disease in 8 patients (80%) and arterial embolism in 2 patients (20%). Surgical revascularization of the limb was attempted but unsuccessful in 9 patients (90%).

Mean follow-up is 25 months (range 6 to 41) and is complete in all patients. Six patients (60%) healed their through-knee amputation stump wound primarily. Two patients (20%) had delayed wound healing (6 weeks and 8 weeks). Two patients (20%) developed wound infection and required amputation revision to the above-knee level. Seven patients (70%) were fitted with a suction socket prosthesis. In 1 patient, the amputation wound healed but she has not been fitted for a prosthesis because of subsequent development of ulceration of the contralateral limb. The 7 patients who successfully healed their through-knee amputation stump wounds and were fit for a suction socket prosthesis are ambulatory and use their prosthesis regularly. One patient who was revised to the above-knee amputation level was fit with a belt-suspended above-knee amputation prosthesis and is ambulatory. Two patients in this series are not ambulatory.

Comments

In 1940, Rogers [1] published a landmark article on the through-knee amputation, a procedure that had fallen into neglect and disrepute after the Civil War. In that article Rogers, a through-knee amputee himself, described the major advantages of through-knee amputation over above-knee amputation that hold true today. The durable through-knee amputation stump allows for end weight bearing, which provides enhanced comfort and proprioception over the ischial weight bearing above-knee amputation stump. The longer lever arm and muscle stabilized femur of the through-knee amputation results in better balance and control of the prosthesis compared with above-knee amputation [3,6,9–13]. Pinzur [2] has shown that the metabolic cost of walking is less and walking stability is enhanced with through-knee amputation compared with above-knee amputation [2]. Others have also shown superior rehabilitation of dysvascular patients who undergo through-knee amputation compared with above-knee amputation [3–6,8,9].

Despite these well-recognized advantages, the procedure has failed to gain widespread acceptance because of the concern that the long skin flaps of the through-knee amputation are prone to wound healing problems, particularly in the patient with peripheral vascular disease [7,8,14] Prosthetists have also had difficulty in designing an acceptable prosthesis for the bulbous stump of the through-knee amputation [15].

Multiple modifications of the through-knee amputation operation have been developed in an attempt to minimize these disadvantages [1,4,6,12,16–19]. Most of the modifications have involved skin flap design and arthrodesis of the

patella. In 1966 Mazet [9] described a technique involving excision of the patella and shaving of the femoral condyles, which reduced the flap length required to close the wound. Critics of this technique noted that the unequal femoral condyles left by the standard knee disarticulation procedure were useful to suspend and "lock into" the prosthesis, and by removing the condyles, supplemental belts or straps would be necessary to maintain rotational stability of the prosthesis. Also, by reducing the area of the weight-bearing surface of the stump, late complications of stump breakdown were more likely to occur [14,16,20].

These criticisms of Mazet's through-knee amputation technique are no longer valid with recent advancements in prosthesis design. In fact, the suction socket design for the conically shaped stump achieved with the technique has significant advantages over the above-knee amputation and standard through-knee amputation sockets. The ischial weight bearing above-knee amputation socket is uncomfortable and must be removed for toileting. The suspension methods for the above-knee amputation prosthesis require lubrication of the limb, application of a sock to the limb, which is used to pull the limb tissue into the socket, or use of belts or straps. Application of the above-knee amputation prosthesis therefore can be a daunting task for the geriatric patient with vascular disease. Consequently, studies have shown that fewer than half of elderly dysvascular amputees who are fit with an above-knee amputation prosthesis use it as their primary mode of mobility, and 19% of above-knee amputees stop using the prosthesis altogether [21,22]. The prosthesis for the conically shaped through-knee amputation stump is easily applied by pushing the stump into the socket while pressing an air release valve at the socket base. The socket maintains the advantages of an end weight-bearing stump but distributes the weight over the entire surface of the stump rather than over the condyles as with the standard through-knee amputation prosthesis. The suction socket of the through-knee amputation is much easier to don and the prosthesis does not need to be removed for toileting. These advantages may increase use of the prosthesis in this patient population. In our series, we have noted no problems with late stump skin breakdown. Also there has been no problem with rotational instability of the prosthesis. No patient in our series has required supplemental belts or straps to maintain stability of their through-knee amputation prosthesis.

Studies have shown healing rates for the through-knee amputation in patients with vascular disease ranging from 73% to 85% [4,6,23]. These results are comparable to the 80% healing rate achieved in our study. In contrast to other studies, however, our study involves a highly selected patient population with severe arterial insufficiency who because of their ischemia or presence of wounds or gangrene of the leg were not candidates even for a short below-knee amputation. Forty percent of the patients in our series had failed to heal a previous below-knee amputation. We believe the healing rate achieved in this series is a result of much shorter skin flaps, which are possible by resecting the condyles and excising the patella.

The functional advantages of below-knee amputation over above-knee amputation are well recognized. Most would agree that these advantages justify the performance of an amputation at the below-knee level in situations where healing is not certain if the patient is a candidate for rehabilitation. Consequently, several large series report nonhealing rates for below-knee amputation approximating 20% in the dysvascular patient population [24–27].

We believe the same rationale should be applied to the through-knee amputation. The through-knee amputation is functionally superior to the above-knee amputation. Therefore, the through-knee amputation level should be considered before above-knee amputation for all patients who are rehabilitation candidates.

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