# Syme Ankle Disarticulation in Patients with Diabetes

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**Background:** Syme ankle disarticulation is an amputation level that minimizes disability and preserves function, but it has been used sparingly in patients with diabetes mellitus. Surgeons have avoided this level because of the perceived high risk for wound failure, wound infection, or migration of the heel pad, which makes prosthesis use difficult.

**Methods:** Ninety-seven adult patients with diabetes mellitus who underwent Syme ankle disarticulation because of a neuropathic foot with an infection or gangrene, or both, during an eleven-year period were studied retrospectively. Selection of the amputation level was made on the basis of clinical examination and an assessment of the wound-healing parameters, i.e., vascular inflow, tissue nutrition, and immunocompetence. The average age of the patients was 53.2 ± 17.5 years.

**Results:** Eighty-two patients (84.5%) ultimately achieved wound-healing. When threshold levels for vascular inflow (ultrasound Doppler ischemic index of 0.5 or transcutaneous partial pressure of oxygen between 20 and 30 mm Hg) and tissue nutrition (serum albumin of 2.5 g/dL) were met, an overall success rate of 88% was achieved. Total lymphocyte count (an absolute lymphocyte count of 1500) and the smoking of cigarettes during the study period did not appear to impact wound-healing rates. The overall infection rate was 23%, and it was three times greater in smokers. Most infections were managed with local wound care and antibiotic therapy. At a minimum follow-up of two years, all but two patients were able to walk with a prosthesis. Thirty of the ninety-seven patients died at an average of 57.1 months following surgery.

**Conclusions:** The results of this retrospective review support the value of Syme ankle disarticulation in diabetic patients with infection or gangrene. This function-sparing amputation can be successfully performed with a reasonable risk. Patients managed with a Syme ankle disarticulation appeared to remain able to walk better and to survive longer than similar patients who had a transtibial amputation and served as historical controls. In diabetic patients with dysvascular disease who have adequate vascular inflow to support wound-healing (an ultrasound Doppler ischemic index of 0.5 or a transcutaneous partial pressure of oxygen between 20 and 30 mm Hg), the threshold for the wound-healing parameter of serum albumin appears to be as low as 2.5 g/dL.

**Level of Evidence:** Therapeutic study, Level IV (case series [no, or historical, control group]). See Instructions to Authors for a complete description of levels of evidence.

The primary indication for lower extremity amputation at the Syme ankle disarticulation level is a nonsalvageable foot infection or gangrene in individuals with diabetes[1-6]. When this amputation is successful, most patients are able to return to their premorbid level of independent walking. Few patients require more than minimal training in the use of a prosthesis. When patients who have had an amputation of the contralateral lower extremity have a Syme ankle disarticulation, they appear to regain the level of functional independence usually associated with the preexisting unilateral amputation[7]. The metabolic and energy cost of walking with use of a prosthesis after ankle disarticulation is not appreciably greater than that in age and sex-matched controls without an amputation, and it is substantially less than that in patients with a transtibial amputation[8-10]. Wagner introduced this amputation as a function-preserving level in diabetic patients, providing guidelines that remain true today[11,12]. He modified the original technique of Syme by performing the surgery in two stages. The first stage was a simple ankle disarticulation. He believed that the cartilage of the distal aspects of the tibia and the fibula would act as a barrier to infection. Six weeks following successful healing of the first stage of the disarticulation, he then removed the medial and lateral malleoli flush with the ankle joint, preserving the weight-bearing cartilage of the distal part of the tibia. Patients were eligible for the operation if they met the following criteria: (1) they had the

potential ability to walk with a prosthesis after rehabilitation, (2) the heel pad was clinically viable, (3) there was no infection at the level of the heel pad, and (4) the vascular inflow was adequate to support wound-healing, as measured by a minimum ankle-brachial index of 0.5 in patients with diabetes and 0.45 in patients without diabetes[11,12].

Currently, the amputation is performed as a single operation because similar results were prospectively obtained in a comparison of the amputation as a one-stage and a two-stage procedure[1]. The commonly observed problem of heel-pad migration has been alleviated either by securing the Achilles tendon to drill-holes in the distal posterior surface of the tibia[13] or by suturing the anterior heel-pad flap to drill-holes in the distal anterior part of the tibia[4,14].

Although Wagner reported a 90% wound-healing rate[12], that level of success could only be reproduced when patients had a sufficient level of tissue nutrition, as evidenced by a threshold serum albumin level of 3.5 g/dL, and immunocompetence, as measured by a threshold total (absolute) lymphocyte count of 1500[15]. (The total lymphocyte count is determined by multiplying the total white blood-cell count by the percentage of lymphocytes in the most recent differential white blood-cell count.) The currently accepted threshold measure of vascular inflow that is capable of supporting wound-healing after an amputation in patients with diabetes is an ankle-brachial index of 0.5 or a transcutaneous partial pressure of oxygen of between 20 and 30 mm Hg, with the patient breathing room air. Two additional currently accepted wound-healing parameters are tissue nutrition, as measured by a serum albumin level of 3.0 g/dL, and immunocompetence, as measured by a total (absolute) lymphocyte count of 1500[3-6,15,16].

The goal of this study was to review our long-term experience with the Syme ankle disarticulation in patients with diabetes mellitus. We specifically attempted to determine the level of functional independence following this procedure and to assess whether our current clinical decision-making guidelines could be supported by our experience.

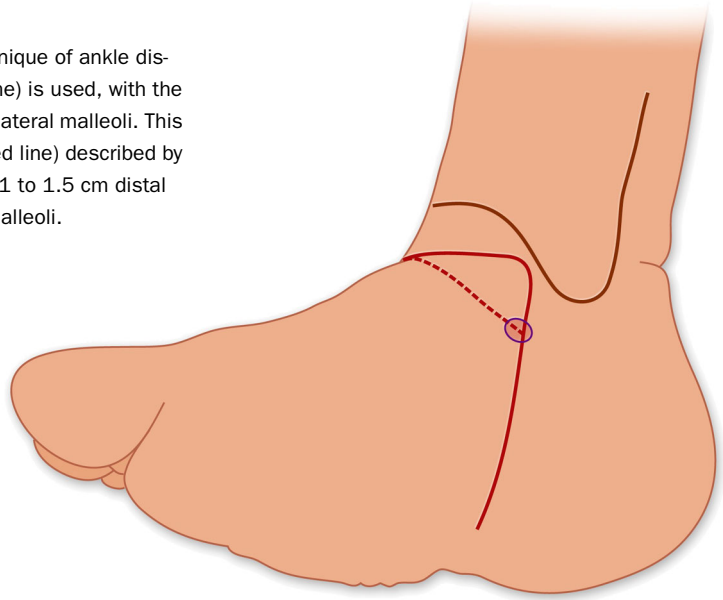
## Methods

This retrospective review encompasses the experience at the Loyola University Medical Center and the Edward Hines Jr. Veterans Affairs Hospital. All operations were performed under the direction of the senior author (M.S.P.), with use of the criteria as described above. Determination of the amputation level was made on the basis of the clinical examination and an assessment of the wound-healing parameters. The threshold vascular inflow was an ultrasound Doppler ischemic (ankle-brachial) index of 0.5 (performed on the posterior tibial artery at the level of the medial malleolus) or transcutaneous oxygen tension, with the patient breathing room air, of between 20 and 30 mm Hg. Measurements of transcutaneous oxygen tension were made at the level of the medial and lateral malleoli, and the recorded value was an average of the two measurements. An effort was made preoperatively to support nutrition and perform the operation when the serum albumin level approached 3.0 g/dL. As a measure of immunocompetence, a target total lymphocyte count of 1500 was also used.

Patients were identified retrospectively with use of a query of the medical records databases of the two institutions back to 1988, identifying all patients who had had a Syme ankle disarticulation and a comorbid diagnosis of diabetes mellitus. Demographic data included the age and sex of the patient, insulin use, and whether the patient was a smoker. Data recorded at the time of surgery included transcutaneous oxygen tension or ankle-brachial index measurements, serum albumin levels, serum total lymphocyte count, and serum creati-

Fig. 1-A

**Figs. 1-A, 1-B, and 1-C** Our current one-stage technique of ankle disarticulation. **Fig. 1-A** A fish-mouth incision (solid line) is used, with the apices at the anterior midpoints of the medial and lateral malleoli. This incision differs from the two-stage technique (dotted line) described by Wagner, in which the apices are located at a point 1 to 1.5 cm distal and anterior to the tips of the medial and lateral malleoli.



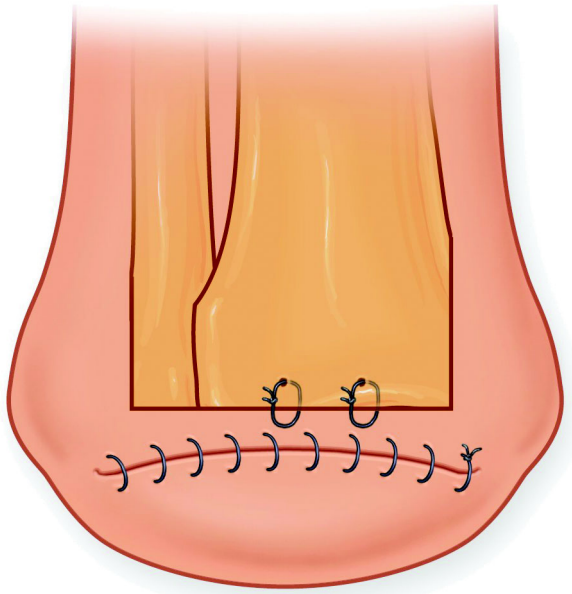


Fig. 1-B
Following disarticulation of the ankle, the malleoli are removed flush with the articular surface of the distal part of the tibia, preserving the articular cartilage of the distal part of the tibia for weight-bearing. The flares of the medial and lateral malleoli are removed with an osteotome in line with the outer aspects of the tibia and the fibula. This improves the cosmetic appearance and creates a raw osseous surface to allow the heel pad to scar securely to the bones.

nine as an indicator of renal function. Charts were reviewed to determine the success or failure of wound-healing, wound infection, and perioperative mortality.

All of the patients were followed for at least two years through the amputee clinics of the two institutions. Ambulatory status was simply divided into three categories. Patients who did not walk with a prosthesis were considered to be wheelchair bound. Patients who used a prosthesis were divided into those who walked only within the house or with assistance when they left the house and those who were independent community walkers. The date of death was obtained through the Department of Veterans Affairs benefits database or by direct contact with the families of the patients at the Loyola University Medical Center.

Ninety-seven patients with diabetes mellitus who had had a Syme ankle disarticulation between January 1, 1988, and December 31, 1999, were identified. The average age (and standard deviation) of the patients was 53.2 ± 17.5 years. There were eighty-six men and eleven women. Fifty-five patients used insulin at the time of the amputation, and forty-two were managed with oral medication or diet alone. Twenty-nine patients were self-categorized as being a "smoker" at the time of the surgery. Patients who admitted to smoking in the past but had not smoked for a period of one year were included in the "non-smoker" group. Serum albumin levels were an average (and standard deviation) of 3.1 ± 0.54 g/dL, and the total (absolute) lymphocyte count was an average of 1673 ± 831. Twelve patients who were managed earlier in the series had the surgery performed in two stages, and the remainder had the surgery performed with use of the following technique.

### *Surgical Technique*

A fish-mouth incision, with the apices of the flaps located at the anterior midpoints of the medial and lateral malleoli, is used (Fig. 1-A). This incision differs slightly from that recommended by Wagner[11,12], in which the apices are located at a point 1 to 1.5 cm anterior and distal to the tips of the medial and lateral malleoli. Moving the apices proximally and posteriorly minimizes the large medial and lateral dog-ears that usually had to be removed at the time of the second stage of Wagner's operation. The incision is carried sharply to bone, and the calcaneus and talus are removed with use of sharp dissection. At this point, the technique follows Wagner's method, with care taken to protect the posterior tibial artery, which is the primary source of blood supply to the distal flap.

Once the ankle is disarticulated, the medial and lateral malleoli are removed flush with the articular surface of the distal part of the tibia, retaining the resilient weight-bearing articular surface of the tibia. The metaphyseal flares of the malleoli are removed flush with the outer aspects of the tibia

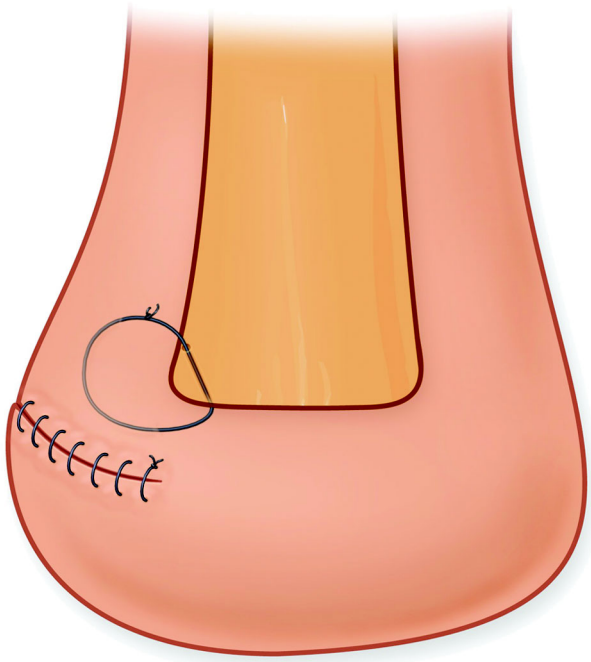


Fig. 1-C
Oblique drill-holes are made in the anterior distal aspect of the tibia. The heel pad is secured to the tibia through these drill-holes with use of nonabsorbable suture.

**TABLE I Data on the Patients at the Time of Surgery**

| | No. of Patients | Failure of Wound-Healing *(no. of patients)* | Rate of Healing *(%)* | P Value | Infection *(no. of patients)* | Rate of Infection *(%)* | P Value |
|---|---|---|---|---|---|---|---|
| Serum albumin | | | | | | | |
| ≤2.5 g/dL | 14 | 5 | 64.3 | 0.02 | 2 | 14.3 | 0.42 |
| >2.5 g/dL | 83 | 10 | 88.0 | | 20 | 24.1 | |
| Total (absolute) lymphocyte count* | | | | | | | |
| <1500 | 43 | 6 | 86.0 | 0.18 | 10 | 23.3 | 0.90 |
| >1500 | 54 | 6 | 88.9 | | 12 | 22.2 | |
| Vascular inflow† | | | | | | | |
| Inadequate | 18 | 6 | 66.7 | 0.02 | 2 | 11.1 | 0.19 |
| Adequate | 79 | 9 | 88.6 | | 20 | 25.3 | |
| Smoker | | | | | | | |
| No | 68 | 9 | 83.8 | 0.35 | 9 | 13.2 | 0.0007 |
| Yes | 29 | 6 | 79.3 | | 13 | 44.8 | |
| Renal function (serum creatinine) | | | | | | | |
| >2.0 mg/dL | 4 | 1 | 75.0 | 0.59 | | | |
| ≤2.0 mg/dL | 93 | 14 | 84.9 | | | | |

*The total lymphocyte count was determined by multiplying the total white blood-cell count by the percentage of lymphocytes in the most recent differential white blood-cell count. †Adequate vascular or arterial inflow was determined by a transcutaneous oxygen tension of 30 mm Hg or by an ultrasound Doppler ankle-brachial index of 0.5.

and the fibula. Two or three oblique drill-holes are then made in the distal anterior aspect of the tibia, and the heel pad is secured to the tibia with nonabsorbable sutures (Figs. 1-B and 1-C). The skin is closed in layers, and a soft dressing is used for five to seven days. At that time, if the heel pad and wound edges appear viable, a total-contact below-the-knee walking cast is applied. The cast is worn until the residual limb volume is sufficiently stable to allow a preparatory prosthetic limb to be fitted.

### *Statistical Analysis*

Differences in proportion were compared with use of the chi-square tests for association. A p value of ≤0.05 was considered to convey a significant difference in proportion.

## Results

The data are presented in Table I. Eighty-two (84.5%) of the ninety-seven patients ultimately achieved wound-healing. We used the currently accepted threshold measure of adequate vascular inflow described earlier, with the understanding that "inadequate" values closely approximated "adequate" values. Despite the fact that the inadequate vascular inflow values closely approximated the threshold values, patients with adequate vascular inflow had a significantly increased rate of ultimate wound-healing ($p < 0.02$). When vascular inflow was deemed adequate and serum albumin was above 2.5 g/dL, a wound-healing rate of 88% was achieved ($p < 0.02$). The targeted total lymphocyte count of 1500, smoking history, and serum creatinine levels (a marker for renal failure) did not appear to have an impact on healing or postoperative wound infection rates; however, infection rates were three times greater in smokers ($p < 0.0007$).

Two patients with a postoperative wound infection had migration of the heel pad, which developed following the postoperative wound infection and removal of the anchoring sutures. Both heel pads were revised surgically, with the heel pad reanchored to the distal part of the tibia with drill-holes.

Eighty of the eighty-two patients who had successful healing of the surgical wounds were able to wear a prosthesis. The walking status of the patients at the time of follow-up is presented in Table II. Thirty of the ninety-seven patients died at an average of 57.1 months (range, eight to 144 months) following surgery.

**TABLE II Function at the Time of Follow-up**

| | Total No. of Patients | Patients with Successful Wound-Healing |
|---|---|---|
| Wheelchair bound | 6 | 2 |
| Household walker | 48 | 40 |
| Community walker | 43 | 40 |

## Discussion

We have always thought that Syme ankle disarticulation was an amputation level that preserved function and independence. It is extremely valuable in diabetic patients, as the only alternative is transtibial amputation, which is associated with a two-year mortality rate of 36%[17]. Most experts would agree that rehabilitation of a patient after an ankle disarticulation is far simpler than rehabilitation of a patient after a transtibial amputation. Patients who have had a Syme amputation rarely require hospitalization in a rehabilitation unit and rarely require more than minimal gait training. Compared with historical standards of survival, these patients appear to survive longer[17]. A third of the patients who had a Syme amputation died an average of five years postoperatively, whereas approximately a third of the patients who had a transtibial amputation died within the first two years following surgery[17]. Patients with a Syme amputation attain a higher level of walking independence than do patients with a transtibial amputation. Only two of the eighty-two patients who had successful healing of the surgical wounds were not able to walk with a prosthesis. It is difficult to determine whether the enhanced survival and level of function are due to the magnitude of the disease at the time of surgery or whether this more distal level of the amputation allowed the patients to be more active and aerobically fit, thus facilitating a greater level of walking independence.

Early in our experience, we adopted the concept that wound-healing was dependent on nutrition and immunocompetence in addition to vascular inflow. We rarely attempted surgery in patients with insufficient vascular inflow, as measured by the ankle-brachial index or transcutaneous oxygen tension at the malleolar levels. The eighteen patients with inadequate vascular inflow had values just below our arbitrary threshold. When vascular inflow was adequate, we came very close to Wagner's so-called gold-standard of a 90% healing rate (Table I).

The original arbitrary choice of a minimum serum albumin level of 3.0 g/dL and a total lymphocyte count of 1500 was based on the literature on preoperative nutritional status and on our experience with patients who had an amputation at the level of the foot or ankle[15,16]. With increasing clinical experience, we noticed that, following resolution of an acute infection, the serum albumin level appeared to rise rapidly. We adopted the practice of performing the definitive Syme ankle disarticulation when the serum albumin began to increase following resolution of an acute infection, and we usually operated when the serum albumin reached 2.5 g/dL. The experience gained from this clinical series allowed us to question the arbitrary threshold level of 3.0 g/dL. At the same time, the data supported our decision to deemphasize the total (absolute) lymphocyte count as a prognostic wound-healing parameter.

With the evolving evidence that vascular surgery performed below the knee is less successful in patients with renal failure, we hoped to determine whether renal failure was an important wound-healing parameter. We had virtually no patients with renal failure (as defined by a serum creatinine of >2.0 mg/dL) because clinical renal failure was almost universally accompanied by the presence of hypoalbuminemia, a condition that did not improve following resolution of the soft-tissue infection, and we were reluctant to perform ankle disarticulation in such patients. The question of the role of renal failure as a function of wound-healing after amputation remains unanswered by this study. This unanswered question likely will become more important with the advent of percutaneous methods of angioplasty, with and without stents, as a method to retain limb viability. Smoking did not appear to be an important factor in achieving ultimate wound-healing; however, the infection rate was three times greater in smokers than in nonsmokers ($p < 0.0007$).

The overall infection rate of >20% speaks to the attention to detail that is necessary to achieve good results in these patients. Virtually all of these infections resolved with local wound care, removal of a few sutures, and culture-specific antibiotic therapy.

Several surgical concepts evolved during the period of this study. The two-stage operation described by Wagner modified the original technique described by Syme so that the articular cartilage of the distal aspect of the tibia was retained. This modification prevented the heel pad from scarring to the metaphyseal surface of the distal part of the tibia, allowing it to be more resilient[11,12]. The present series supports the use of a one-stage technique that retains the resilient, weight-bearing distal tibial articular cartilage. Smith and Bowker added modifications that prevent migration of the heel pad, a complication that either precludes prosthetic use or makes prosthetic fitting much more complex[4,13,14]. We found that anchoring the heel pad to the distal aspect of the tibia virtually eliminated the problem of heel-pad migration. We had only two patients in whom this complication developed, and both complications were secondary to wound infection and removal of the nonabsorbable anchoring sutures. Following resolution of the infection, both patients had a successful surgical revision.

The present retrospective review should lay to rest several popular misconceptions about ankle disarticulation in diabetic patients. The procedure can be carried out with a success rate of approximately 90%, as originally predicted by Wagner, providing that patients have adequate arterial inflow and a minimum level of tissue nutrition, as reflected by a serum albumin concentration as low as 2.5 g/dL. Only one of our patients required a late revision to a more proximal level, and that operation was performed approximately five years postoperatively. With use of the surgical modifications described, we had only two patients with heel-pad migration and both had a postoperative wound infection. While patients with diabetes have extensive multiple organ system disease, they can resume their premorbid activity level with a low risk of wound failure. The findings in the present study support the use of this reliable and valuable amputation level in diabetic and/or dysvascular patients. ■

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