The Boyd Amputation as a Treatment for Osteomyelitis of the Foot

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The Boyd amputation is a surgical technique used to treat osteomyelitis of the foot. This amputation is a technically more difficult procedure to perform than the Syme amputation, but it offers certain advantages. The Boyd amputation provides a more solid stump because it preserves the function of the plantar heel pad. Also, because a portion of the calcaneus is left and fused to the tibia, the weightbearing surface is more solid than in the case of a Syme amputation. The authors recommend a Boyd amputation as an alternative to a Syme or a below-the-knee amputation to treat patients with osteomyelitis of the forefoot and midfoot. (J Am Podiatr Med Assoc 90(5): 234-239, 2000)

Diabetic foot infections often require treatment by amputation.[1-3] Peripheral vascular disease and some degree of neuropathy are the primary causes of infection in people with diabetes; these conditions may lead to osteomyelitis. In cases of osteomyelitis, either acute or chronic, an amputation can eliminate the infection and restore the patient to normal health in a relatively short period of time.[4] There are many different levels of amputation for the foot and ankle. This article describes the Boyd amputation as a procedure for resection of osteomyelitis in the foot.

Historical Perspective

In 1939, Dr. Harold B. Boyd[5] first described a surgical technique for amputation of the foot involving calcaneotibial fusion. Boyd stated that the operation was more advantageous, both from an anatomical and from a physiologic standpoint, than other amputations through the region of the ankle or the tarsus.

The Boyd amputation has been used since the early 1960s to treat children with congenital absence of the fibula.[6] The primary indications for the use of the Boyd amputation are congenital or acquired foot deformity and morbid limb-length discrepancy.[7] Other indications include congenital tibial deficiency, congenital femoral deficiency, injury, osteomyelitis, hemangiomatosis, congenital pseudarthrosis of the tibia, and multiple enchondromatosis. There has never been a large study reported in the literature examining the use of the Boyd amputation for osteomyelitis.

The Boyd amputation is a modification of the Syme amputation. James Syme first described his procedure in 1843.[8] The operative technique is now well known and has been described in detail by several authors, including Aldredge and Thompson[9] and Wilson.[10] The original procedure was performed by Syme in 1842 on a 16-year-old boy with a chronic foot infection. The advantage of his technique over a more proximal-level amputation is the more durable weightbearing stump that results.

Syme was an admirer of François Chopart (1743–1795) and had a particular interest in Chopart's disarticulation method. Syme was the first surgeon to use Chopart's method of amputation in Great Britain. However, as the foot infection in Syme's original case involving the 16-year-old boy extended beyond the limits of the level described in Chopart's method, he decided to perform a more proximal amputation.

Lindqvist and Riska[11] surveyed 21 cases of amputation that were performed at the level described by Chopart, Pirogoff, and Syme. The Syme amputation

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has been used principally for treatment of congenital deformity of the foot and trauma. This method is also indicated for treatment of wet or dry gangrene of the foot in patients with peripheral vascular disease.[12] Fewer cases have been reported of the use of the Syme amputation for treatment of osteomyelitis.

Gaine and McCreath[13] have discussed the advantages and disadvantages of the Syme amputation. Some of the advantages are the ability to bear weight on the stump, the patient's view that the method is a less destructive amputation in that more of the foot is retained, and better proprioceptive feedback about the position of the remaining stump in relation to the leg.

Other authors, like Boyd, have proposed variations of Syme's original procedure. Long before Boyd, and after experience in treating military personnel during the Crimean War, Pirogoff,[14] in 1854, described how to create a division through the calcaneus to allow a longer weightbearing stump. His operations were performed in order to resect bones and joints as well as shells, bullets, and infected tissues. In 1956, Harris[15] stressed the importance of preserving the plantar fat pad when performing a Syme amputation. He stated that the hydraulic cushioning effect of the heel pad should be preserved by careful subperiosteal dissection when the calcaneus is removed. Sarmiento et al,[16] in 1966, described a modification of Syme's procedure involving trimming the malleoli that reduced the mediolateral diameter of the stump by approximately one-third.

A two-stage amputation procedure was developed to increase the success rate when active infection is present. Although Wagner[17] is given credit for first describing this procedure in his 1977 report, one case was initially reported by Hulnick et al[18] in 1949. Spittler et al[19] were the first authors to describe and use the two-stage Syme amputation in a large study. They performed 36 operations on 34 patients between 1946 and 1952. Thirty of those patients (88%) were eventually able to use prostheses on a daily basis. The average follow-up time was 1 year and 6 months.

Eilert and Jayakumar[20] compared the use of the Boyd and Syme amputations in order to determine which was superior. They performed 14 Syme amputations and 23 Boyd amputations, and monitored the patients' progress for 3 to 16 years. They found that the Boyd technique was a more dependable method of obtaining heel pad alignment in the plantigrade position, but was a more technically difficult procedure to perform. They concluded that there was no distinct advantage of one amputation technique over the other.

Fulp et al[21] reviewed the results of a study of 31 amputations. Of these 31, 15 were Syme amputations and 16 were Boyd amputations. They were performed for longitudinal deficiency of the fibula. The median duration of follow-up was 8 years and 10 months. The patients who had been treated with a Syme amputation had more problems related to re-formation of the calcaneus, heel pad instability, excessive length of the residual extremity, and prosthetic suspension. The authors found that the Boyd amputation was associated with better function of the heel pad and the prosthetic suspension and provided the optimum length of the residual extremity.

A modification of the Boyd amputation was reported by Kornah.[22] Three patients (average age, 28 years) had sustained foot injuries in the war in Afghanistan; they had lost the forefoot and showed equinus deformity of the remaining rearfoot. The author states a goal of trying to save as much of the foot as possible to avoid a higher level of amputation. He describes using the talus as a bone graft and reshaping it and fusing it to the tibia, while also retaining the calcaneus. The follow-up period was 12 months; at the end of that period, all of the patients had remained healed and none required a prosthesis.

Surgical Procedure

The technique for the Boyd amputation has been described by Tooms and Richardson.[23] The procedure used at the authors' institution is as follows. First, the skin incisions are marked on the patient's foot. Figure 1 shows the anterior view of a foot with the planned skin incisions. The lateral view of the skin incision is shown in Figure 2. Care is taken to extend

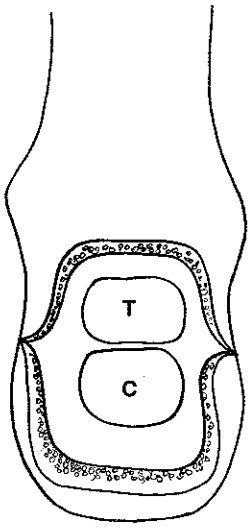

Figure 1. Anterior view of the skin incisions with the talus superior to the calcaneus. C, calcaneus; T, talus.

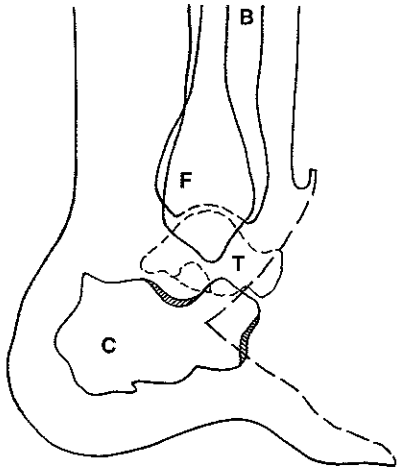

Figure 2. Lateral view of the skin incision showing the outline of the portion of the talus to be excised. C, calcaneus; T, talus; F, fibula; B, tibia.

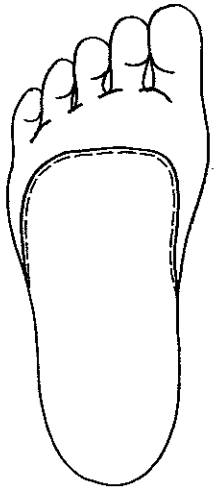

Figure 3. Plantar view of the skin incision. The incision should be as far distal as possible.

the plantar incision as far distally as possible in order to preserve as much of the plantar flap as possible (Fig. 3). A Whitman talectomy is performed after the initial dissection is begun.[24] The authors have found a meniscotome to be useful in dissecting the talocalcaneal interosseous ligaments. The osteotomies are then made in the calcaneus. The anterior process (Fig. 4), sustentaculum tali (Fig. 5), and posterior and middle facets (Fig. 6) are cut with a sagittal saw. The authors try to position the calcaneus in a rectus-to-valgus orientation.

One method of fixation involves making two stab incisions in the skin at the distal lateral and medial aspect of the leg. Guide wires are passed from superior to inferior so that they just exit the tibia. This should be done under fluoroscopy to visualize the proper alignment. Once these guide wires are crossed and in place, two 6.5-mm cannulated cancellous screws are passed over the wires. The wires are removed and screw alignment is confirmed under direct fluoroscopy. In addition, a recent modification to the procedure is resection of the lateral portion of the malleolus at a 45° angle to prevent future breakdown at this site (Fig. 7). Finally, closure is accomplished with interrupted sutures or staples and a drain is inserted for 48 to 72 hours.

Another fixation technique requires the use of a revision nail. This is an intramedullary nail that is inserted plantarly through the calcaneus and is driven superiorly into the tibia. Screws are inserted into the

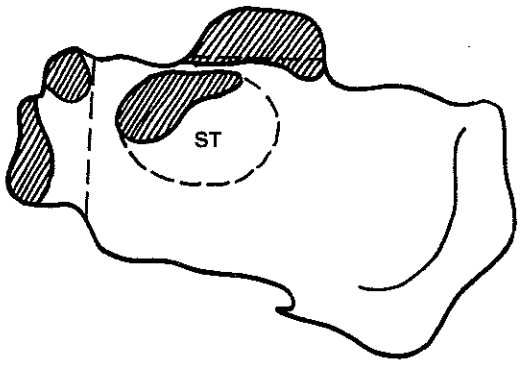

Figure 4. Anterior process of the osteotomy of the calcaneus. ST, sustentaculum tali.

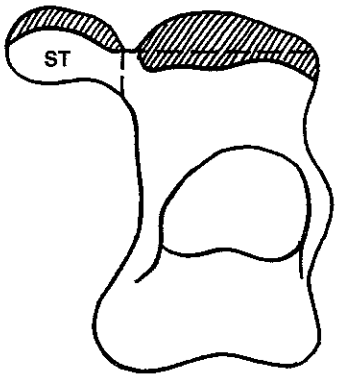

Figure 5. Sustentaculum tali osteotomy. ST, sustentaculum tali.

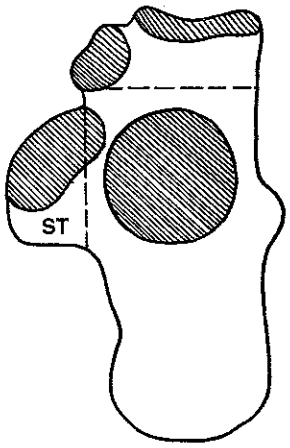

Figure 6. Posterior and middle facet osteotomies. ST, sustentaculum tali.

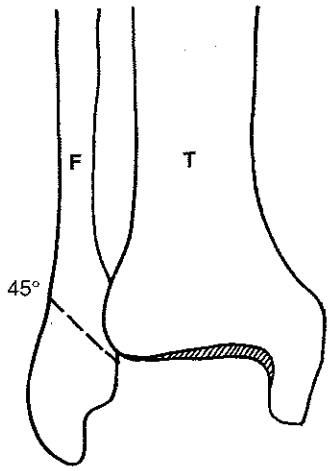

Figure 7. The 45° cut of the fibula. F, fibula; T, tibia.

nail for proper fixation (Fig. 8). This has proved to be an even more effective means than the guide wire method of holding the calcaneus in the proper position and has provided a more solid weightbearing stump. This revision nail technique is now the preferred method of fixation.

Postoperatively, the patient remains nonweightbearing for 4 weeks. Ambulation is then encouraged for 4 weeks in a removable cast with an additional heel cushion of a shock-absorbing material. The patient is then ready to be fitted with a prosthetic device and should be ready to walk unassisted by 3 months after surgery.

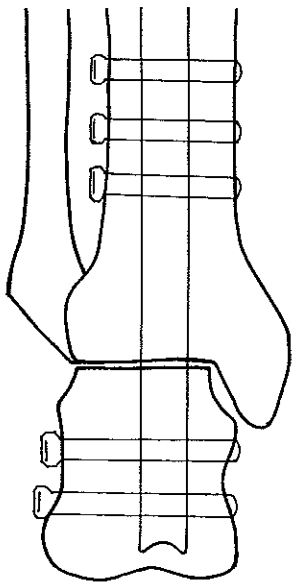

Figure 8. Final positioning with the nail and screws in place.

Case Report

A 46-year-old man was admitted to the Veterans Affairs Chicago Health Care System, Westside Division, because of an ulcer under the third metatarsal head of the right foot that had exposed bone and was not healing. The ulcer had been present for approximately 6 months. The patient had been seen weekly in the outpatient clinic and had been treated with a variety of wound-care products, accommodative footwear, oral antibiotics, and sharp debridement. All of these measures had been unsuccessful in healing the ulcer.

The patient was unemployed. He had a 20-year history of type 2 diabetes mellitus. He had a history of alcohol abuse and a five pack-year history of cigarette smoking. He had used cocaine occasionally in the past, but denied intravenous drug abuse. He was allergic to penicillin.

The patient was a well-developed, well-nourished man in no apparent distress. Physical examination on admittance to the hospital revealed the following findings: temperature, 98.8° F; pulse, 88 beats per minute; respirations, 18 per minute; blood pressure, 110/70 mm Hg in the supine position. The ear, nose, and throat examination was unremarkable. The cardiovascular examination revealed normal first and second heart sounds with neither third nor fourth

heart sounds on auscultation, regular rate and rhythm, and no murmur. The lungs were both clear to auscultation. There were normal active bowel sounds, with no scars and no tenderness in the abdomen. Examination of the extremities revealed right footdrop secondary to a gunshot wound in 1975. Muscle strength was 5/5 in both of the upper extremities and in the left lower extremity. The right lower extremity had no dorsiflexion power, but all other muscle groups were intact. Achilles tendon and patellar reflexes were +2 on the left side and +1 on the right side. The patient had sensory loss to all aspects of the right foot when tested with a 5.07 Semmes-Weinstein monofilament. The ulcer was located under the third metatarsal head of the right foot. The first and second digits on the right foot had been previously amputated in 1975 because of infection. The ulcer measured $2.5 \times 2.0 \times 1.0$ cm and had a granulating base and a hyperkeratotic border with bone exposed. There were no signs of cellulitis, and there was minimal drainage.

The remarkable laboratory results were as follows: white blood cell count, 4,900/μL; glucose, 180 mg/dL; erythrocyte sedimentation rate, 52 mm/h; hemoglobin, 13.1 g/dL; and hematocrit, 37.6%. The patient's wound cultures consistently grew *Staphylococcus aureus*. Blood cultures were negative for any growth of aerobic or anaerobic organisms. The electrocardiogram showed a normal sinus rhythm.

The patient was taking the following medications: glyburide, 2.5 mg/day; ciprofloxacin, 750 mg, by mouth, twice daily; clindamycin, 300 mg, by mouth, every 6 hours; acetaminophen, 325 mg/codeine, 30 mg, as needed for pain; and a multivitamin tablet daily. Radiographs of the right foot showed distal tapering of the third metatarsal with periosteal bone formation, a finding consistent with osteomyelitis. Sclerosis was also noted in the cuneiforms. A three-phase technetium-99m bone scan revealed increased uptake in the delayed phase at the second and third metatarsals, also consistent with osteomyelitis. The bone scan was ordered so that the level of suspected infection could be delineated. Increased uptake was also noted in the tarsal bones. Because the calcaneus did not show any uptake in the delayed phase, the authors were fairly certain that the suspected osteomyelitis had not yet invaded the calcaneus. Noninvasive arterial blood flow studies were obtained, which revealed triphasic wave forms at the dorsalis pedis, posterior tibial, and popliteal arteries. Other findings were pressures of 70 mm Hg at the third toe and 110 mm Hg at the transmetatarsal level with an ankle-brachial index of 0.9.

The patient underwent a Boyd amputation of the right foot under intravenous sedation with a regional anesthetic block. The femoral, lateral femoral cutaneous, obturator, and sciatic nerves were blocked. He tolerated the procedure and anesthesia well, and there were no intraoperative complications. Postoperative radiographs are shown in Figure 9.

The pathology report revealed multiple areas of plasma cells as well as inflammatory responses consistent with osteomyelitis. The demineralization process confirmed the presence of osteomyelitis microscopically. The microbiology results of the bone specimen revealed *S aureus*, which was sensitive to doxycycline. The organism was not methicillin-resistant.

Wound dehiscence occurred on the third postoperative day. A stable eschar formed on the distal plantar aspect of the stump. The patient was compliant and remained strictly nonweightbearing. Saline wet-to-dry dressings were changed four times daily. There was

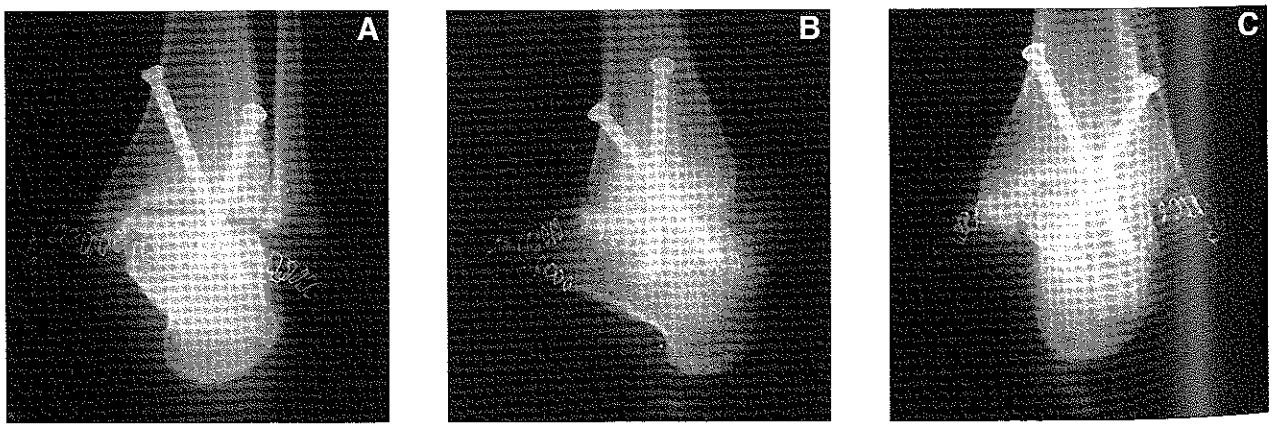

Figure 9. Postoperative radiographs: A, anteroposterior view; B, lateral view; C, oblique view.

granulation tissue and fibrotic tissue dorsal and central to the wound. No exposed bone was noted.

The patient was kept on a 6-week course of intravenous piggyback administration of antibiotics (doxycyline, 100 mg every 12 hours). A drain culture was obtained after 2 days and was positive for *S aureus*, which was susceptible to doxycycline and resistant to all other available antibiotic choices.

The patient was discharged to home on postoperative day 39. The wound was still open, but was very healthy and granulating. Both aerobic and anaerobic cultures of the wound at this point showed no growth. The patient was placed in a temporary Syme prosthesis and encouraged to walk at 7 weeks postoperatively. At the time of this writing, he was 2 years postoperation and completely healed. He has been fitted with a prosthetic device and is walking and driving a car without difficulty. He realizes the importance of keeping his stump intact to prevent the loss of his leg.

Conclusion

The Boyd amputation is a viable option for treatment of osteomyelitis of the foot. It should be considered in patients for whom a Syme or below-the-knee amputation is being discussed. To quote Dr. Boyd, "Do not be wedded to one method. The good surgeon, like the good golfer, has many clubs in his bag, and goes to great pains to use the correct one for each shot."[25]

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