Is Boyd’s Operation a Last Solution that May Prevent Major Amputations in Diabetic Foot Patients?

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We had several difficulties in dealing with diabetic foot lesions and infections at the level of midfoot and hindfoot. At this level of the foot, bone and joint involvement is quite common. We had to perform major amputations in most of these patients. As our search to overcome this problem continued, we concluded that the relationship between infection, necrosis, and hypovascular tissue is very strong in this part of the foot. At the end, we have seen that Boyd’s operation can break this vicious cycle. Boyd’s operation consists of talectomy, excision of articular surfaces of tibia and calcaneus, and tibiocalcaneal arthrodesis. It can be performed as single or 2-staged operation depending on clinical judgment. After the first stage of operation, the defect is left open for a period. With local wound care, the defect is prepared for definitive closure and closed secondarily. We have performed Boyd’s operation in 16 patients with diabetic foot lesions and infections reaching midfoot and hindfoot regions. In 15 patients, complete healing was achieved and these patients were able to walk themselves. Mean follow-up period was 3.2 years. Most of the time the heel region and calcaneus are not on the pathways of severe foot infections. Therefore, the most important criterion that is necessary to perform Boyd’s operation usually do exist. After the Boyd’s operation, an optimal condition for wound healing is achieved by removing all bradytrophic (hypovascular) tissues in the foot. Boyd’s operation is superior to other partial midfoot and hindfoot amputations in terms of anatomy and function. Level of Clinical Evidence: 4. (The Journal of Foot & Ankle Surgery 47(4):307–312, 2008)

Key Words: amputation, Boyd’s operation, diabetic foot, ulcer, wound

Foot deformities occur because of atrophy of intrinsic muscles of the foot. Loss of elasticity and flexibility lead to a relatively rigid and unstable foot with altered weight-bearing areas. The combination of various risk factors in the presence of neuropathy increases the plantar pressures significantly in the forefoot. Seventy-five percent of diabetic foot lesions and infections start at the level of the forefoot. Seventy-five percent of diabetic foot lesions and infections start at the level of the forefoot. At this level, treatment of lesions is easier than midfoot and hindfoot levels. Proximal metatarsal head is the last and most important key point. The lesions beyond this point reach midfoot. At the end, we are faced with new difficulties in treatment.

The lesions and infections involving bones and joints in the midfoot region are the most difficult to treat among all diabetic foot lesions. In this region, there are many bones that are generally cubical in shape. They are arranged as keystones and have many joint surfaces. Many fibroreticular ligaments exist between these bones. Furthermore, most of these tissues are hypovascular. The progress of infection and necrosis throughout these joints and involvement of new bones poses a surgical challenge. Most of the time heel fat pad region and calcaneus are not on the pathways of severe foot infections. With serial debridements, it becomes even impossible to stop progression of infection and necrosis at the level of Lisfranc and Chopart joints and eventually most of the lesions become hindfoot lesions. At this point, tibiotalar and talocalcaneal joints are challenges for treatment. At last, only one surgical procedure is left to prevent major amputation and that is tecomia and calcaneotibial arthrodesis. Syme amputation is also an option at this level. It is a surgical procedure that involves an ankle disarticulation with removal of the both malleoli and forward rotation of the heel pad over the end of the residual tibia.

Talectomy and calcaneotibial arthrodesis procedure was first described by Boyd in 1939 (1). In spite of a having a long history, it was used less frequently and it was less popular than other partial midfoot and hindfoot amputations.

After analyzing the pathophysiology of diabetic foot le-
sions and under the guidance of advances in wound care in the past decade, we have performed Boyd’s operation for the solution of progressive diabetic foot lesions that might have resulted in major limb loss.

**Patients and Methods**

**Patients**

We performed Boyd’s operation on 16 diabetic foot patients between March 1993 and April 2006 (Table 1). All patients were evaluated retrospectively and all outcomes were based on chart review. As an observational case series study, our study has some limitations. These limitations are measurement and selection biases, lack of a control group, and lack of inferential statistical analyses.

Five patients were female and 11 were male. The mean age of patients was 52.4 years. Mean duration of diabetes mellitus (DM) was 13.5 years. At the time of admission, all lesions were present at the level of midfoot or hindfoot bones. Tibiotalar arthritis was present in 4 patients and talocalcaneal arthritis was present in 5 patients. There was no heel fat pad involvement in any of patients. None of the patients was ambulating preoperatively.

In 9 patients at least one of the distal pulses was palpable; in 7 patients no distal pulses were palpable. In 2 patients popliteal arteries were also nonpalpable.

In all patients, serial debridements, antibiotherapy according to the result of culture antibiogram, and energetic local wound care program were applied before the definitive surgery. Wet-absorbent dressings and dressings coated with silver were used until the wound was ready for the surgery.

In 4 patients, single-staged Boyd’s operation was performed. In 12 patients, because of the high risk of infection, taeectomy, resection of articular surfaces, and arthrodesis with Kirchner wires were done in the first stage and the wound was left open. Wet-absorbent dressing was used until the second stage of the operation. After about 14 days, the second stage was performed and the wound was closed secondarily.

**Surgical Technique**

A fish-mouth incision is done between medial and lateral malleolus. Plantar flap is kept longer than the dorsal flap (Figure 1). After preparation of the flaps and providing a sufficient space, all ligaments that hold talus are cut. Removal of talus is one of the most difficult parts of the operation. This maneuver may require excision of the lateral malleolus. After removal of talus, all joint surfaces are resected with osteotomes and bone cutters. Calcaneus is pushed forward and fixed to the tibia with Kirchner wires without leaving a dead space between them. Then the arthrodesis site is covered by muscle parts of the flaps. Wet to wet dressing is applied over muscle flaps.

**Case Reports**

**Case 1**

A 53-year-old male patient was admitted to us due to a lesion involving the medial aspect of the right foot after an unsuccessful partial foot amputation done in another clinic (Figure 2). There was necrosis of the soft tissues and forefoot and midfoot bones and joints. Both dorsalis pedis and tibialis posterior arteries were nonpalpable. Two-staged Boyd’s operation was planned for this patient. After a sufficient wound preparation, Boyd’s operation was done successfully.
Case 2

A 54-year-old male patient was admitted to us with complaints of wet gangrene and acute infection on the lateral aspect of his left forefoot and midfoot (Figure 3). His distal pedal pulses were both nonpalpable. He had femoropopliteal bypass surgery. After serial debridements and minor amputations, the wound was ready for definitive surgery. Two-staged Boyd’s amputation was performed in this patient. At postoperative seventh month, the wound was completely healed.

Case 3

A 35-year-old male patient was admitted to hospital with the complaint of deformation on his right foot and a non-healing ulcer on the lateral aspect of the foot (Figure 4).
Evident Charcot arthropathy was present in this patient. Two-staged Boyd’s operation was performed successfully. All lesions were completely healed at the postoperative third month visit.

**Results**

In 13 patients, complete healing was achieved after a perfect postoperative period. In three patients, serious infections and necrosis were seen after the definitive closing surgical procedure. In these patients, we removed Kirchner wires and we moved to open wound care program. In 2 of these patients, we had achieved optimal wound conditions to perform arthrodesis again and were successful. In other patient, we could not control infection and necrosis and we had to perform transtibial amputation. Our median follow-up period was 3.2 years (4 months to 12 years). All of the patients were able to walk themselves without special prosthetics in a short period. Boyd’s operation resulted in about 5 to 6 centimeters of shortness of the affected limb and this is compensated with the use of custom-made high-heeled shoes.

**Discussion**

In diabetic foot lesions and infections there is frequently involvement of the bone and joints that increases complexity of these lesions. Surgical technique is chosen according to this involvement and the technique is named according to the level of amputated bone or bones.

Since anatomical structure of the forefoot region is not complex, the treatment principles and surgical plan of forefoot lesions with bone and/or joint involvement will be understood easily. Most of the time in this region stopping the progress of lesions and infection, preparing the wound for surgery, and accelerating wound healing will be easy.

The main complexity and difficulty in diabetic foot wound pathophysiology and healing starts at the proximal metatarsal region and continues all throughout the midfoot region. Consisting of many short bones and joint surfaces, arrangement style of these bones in the midfoot region makes control of infection and necrosis difficult even in palpable distal pulses. Even at the level of Chopart joint, this situation is not different. For these reasons, most midfoot lesions become hindfoot lesions.

Technically, in spite of being a difficult operation compared to other hindfoot amputations since most of avascular and hypovascular tissues are removed in this operation, there is an optimal tissue composition left behind that provides better wound healing.

After removal of talus, with the help of plantar muscle flaps, the ankylosis region, which is very critical and important, will be covered at the front and side zones. Achilles tendon shortening and equines deformity of the foot resulting from long-lasting infections will disappear automatically. In addition to this, removal of talus diminishes the size of the amputation stump, which provides easy closure of the defect with skin of the foot itself. Boyd amputation results 4- to 5-cm shortness in the length of the extremity and ankylosis of joints. In my opinion, shortness of extremity and ankylosis facilitate walking and increase foot stabil-
ity. With this technique, we did not need extra operations such as achilloplasty or anterior tendon reinsertion in these patients.

The Boyd’s operation has been used for children with congenital absence of fibula for many years (2). Boyd stated that “the operation is more advantageous, both from an anatomical and from a physiologic standpoint, than other amputations through the region of the ankle or the tarsus (1).” Syme amputation was used extensively during World War II in treatment of battlefield injuries (3). The results were superior to those afforded by below-knee amputations. In 1976, Eilert and Jayakumar (4) compared the results of Boyd amputation with those of the Syme amputation in children. They concluded that the Boyd technique provided “a surer method of obtaining an intact plantigrade heel pad.” Blum and Kalamchi (5) performed Boyd amputation in children with congenital or acquired foot deformity. They concluded that since with the Boyd amputation the distal tibial epiphyseal growth plate is retained, length is maximized, and the hydraulic heel pad cushion is preserved, it is the most advantageous technique for ablating the foot in children. We realized that publications about this technique were not frequently seen in the literature and whether it could be used for diabetic foot patients was not clear. Grady and Winters (6) had performed a Boyd amputation in a patient with osteomyelitis of the foot. They concluded that “Boyd amputation is a viable option for treatment of osteomyelitis of the foot and it should be considered in patients for whom a Syme or below-the-knee amputation is being discussed.”

Severe plantar flexion (equinus deformity) and eventual stump breakdown may develop after Chopart amputation. Lieberman et al (7) performed Chopart amputation with percutaneous heel cord lengthening and had a 36% overall failure rate. With Boyd’s operation, classical complications of the Chopart’s amputation can be avoided.

Boyd’s operation has advantages over Syme amputation in terms of walking, foot stability, and rebalancing. Besides, backward migration of the heel fat pad and shortening that may occur long term in Syme amputation is not seen in Boyd’s operation.

It is very important before the surgery to know whether blood flow to the extremity will be enough for wound healing, especially for patients with severe circulation problems in the lower extremity. We can determine this with the help of many laboratory testing and radiological studies such as angiography. We believe that the amount and speed of bleeding and tissue viability during debridements will guide us truly in these cases (8, 9). We had successful results with Boyd’s operation in 2 patients without palpable distal pedal pulses based on perioperative clinical observation.

All patients that we operated were candidates for a major amputation procedure. The fear of losing a leg created serious psychological disturbances for the patients and the patients’ relatives. After a successful Boyd’s operation, we have seen that patients had a good living will and were happy with the results.

**Conclusion**

Most of the time, the heel pad region is not on the pathway of diabetic foot infections. Besides, in most diabetic foot patients at least one of the distal pulses is positive. This means that most of the lesions can be treated with well-executed surgery. Boyd’s operation is one of the difficult and complex operations of the foot in terms of indi-

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**TABLE 1 Patients’ characteristics**

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<tr>
<th>Patient</th>
<th>Sex</th>
<th>Age</th>
<th>DM duration, y</th>
<th>Comorbidities</th>
<th>Vascular exam (pop/tp/dp)*</th>
<th>Complication</th>
<th>Result</th>
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*DM, diabetes mellitus; F, female; M, male; pop, popliteal artery; tp, posterior tibial artery; dp, dorsalis pedis artery.
cation, planning, and technique. For this reason, with the knowledge, experience, and performance gained from other foot operations it can only be coped with. The structure of the foot after Boyd’s operation has the best functional late results in addition to having residual healthy tissue composition and good wound healing. It is a less destructive amputation from the patients’ point of view compared to other major amputations.

References