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A new limb-salvaging technique for the treatment of late stage complicated Charcot foot deformity: Two-staged Boyd's operation

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ABSTRACT

Background: Depending on the stage of disease, several operative and non-operative treatment options exist for diabetic patients with Charcot foot deformity. In the early stages of the disease, the most effective treatment is total-contact cast application. In patients with multiple bone fractures and deformations, surgical interventions are generally required for the reconstruction of foot architecture. Exostectomy, osteotomy, arthrodesis, and internal–external fixation are some of these operative methods. However, recurrence of ulcer and infection is very likely following these surgical procedures. If the lesion and infection reach to midfoot and hindfoot region, a major amputation is usually required for treatment.

Methods: We have been performing Boyd's operation for the last 10 years in diabetic foot patients who had complicated lesions in midfoot and hindfoot regions. Furthermore, since 2004, we have been doing the same operation for complicated Charcot foot deformities. So far, we have treated 11 patients.

Results: The mean age of the patients was 53.4 ± 10.2 years, and the mean duration of diabetes mellitus (DM) was 17.5 ± 7.2 years. All patients had chronic infections with fractures of the tarsal bones for at least 2 years. Durable wound coverage and ankylosis were achieved in all patients with two-staged Boyd's operation. No recurrence is detected in any of the patients during mean post-operative follow-up period of 2.1 ± 0.8 years.

Conclusion: Boyd's operation is a reliable option for the treatment of patients with late stage Chatcot foot deformity.

1. Introduction

Although Charcot foot deformity was first described by a neurologist Jean-Martin Charcot in 1868 in a group of patients with syphilis, today it is known as one of the late complications of diabetes mellitus. The condition is characterized by multiple joint dislocations and pathological fractures with progressive, destructive neuro-osteoarthropathy leading to destruction of the foot architecture.

In the early stages of the disease, the progression of deformity can be reversed with early diagnosis and treatment, particularly by unloading the affected limb. Delayed diagnosis, misdiagnosis or mistreatment, difficulties in re-adjustment of the disorganized anatomical structures, and most importantly, continuous weight bearing on the severely deformed neuropathic foot can lead to progression of destruction with complicated lesions and infections of the foot. These lesions and infections are very difficult to treat when they spread to deeper structures such as bones and joints. At this stage all treatment efforts would possibly be ineffective and major amputations would be inevitable. Therefore, for years, many surgeons believed that major amputation was the appropriate choice in patients with complicated late stage Charcot foot deformities with concomitant infections. However, this opinion has changed significantly for last 10 years. With advancement in wound treatment strategies, wound healing is faster and better today. We have used advanced open wound care methods while we perform Boyd's operation in diabetic foot patients [1]. Furthermore we started doing Boyd's operation in complicated late stage Charcot foot deformities with the help of this experience gained from previous operations.

The purpose of this study was to show our experience with Boyd's operation in patients with complicated Charcot foot deformities in whom otherwise a major amputation was indicated for treatment.

2. Patients and methods

2.1. Patients

Between January 2004 and December 2008, we have performed two-staged Boyd's operation in 11 patients with complicated late

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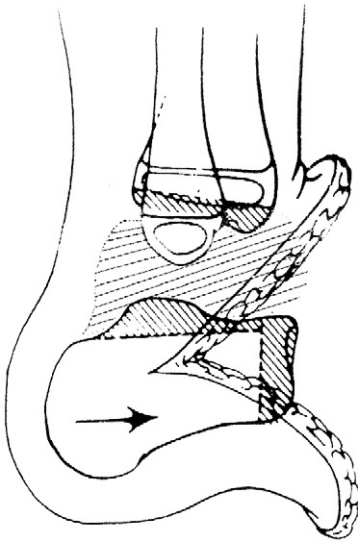

Fig. 1. Schematic drawing of Boyd's operation. Shaded areas are removed.

stage Charcot foot deformity (Table 1). Five of the patients (45%) were male. The mean age of the patients was 53.4 ± 10.2 years, ranging from 35 to 68 years. The mean duration of diabetes mellitus (DM) was 17.5 ± 7.2 years. In 9 of 11 patients (82%), both pedal pulses were palpable. In 2 patients, dorsalis pedis artery was palpable, but posterior tibial artery was non-palpable. Multiple calcaneal fractures were present in 4 patients. Very severe neuropathy was detected in all patients on admission.

Charcot foot deformity was complicated with chronic lesions and infection for a mean duration of 2 years. Once patients were hospitalized, abscesses were drained and fistulae orifices were dilated carefully. By this way, sequestrectomy, debridement and effective dressing were performed. Deep tissue samples were obtained for antimicrobial susceptibility tests. Following an energic wound care program and systemic antibiotherapy for 1–2 weeks, first stage of Boyd's operation was performed. In first stage, talectomy, resection of the all articular surfaces and tibiocalcaneal arthrodesis was performed using a pair of K wires. If during the surgery, it is determined that the wound was clean and viable bleeding tissue was present, the amputation stump was covered with dorsal and plantar skin–muscle flaps. In patients with a high risk of infection, the wound was left open without doing tibiocalcaneal arthrodesis.

After approximately 2–3 weeks of open wound care, second stage of the operation was done. In the second stage, tibiocalcaneal arthrodesis was carried out if it was not performed in the first stage. Then, the arthrodesis region was covered with plantar local muscle flap. The stump was closed with approximation of plantar and dorsal skin flaps carefully.

2.2. Surgical technique

Talectomy and calcaneotibial arthrodesis procedure was first described by Boyd in 1939 [16]. In original description it was a one-stage operation. However we did two-staged operation in this study since the probability of infection was very high in these patients.

All operations were done with the help of a trapezoid pillow that we use routinely in our diabetic foot operations [2]. A fish-mouth incision was made between the medial and the lateral malleoli. The plantar flap was kept longer than the dorsal flap (Fig. 1). Once the flaps were prepared, all ligaments that hold the talus were cut. Removal of the talus is one of the most difficult parts of the operation. This maneuver may require excision of the lateral malleolus. After removal of the talus, all joint surfaces were removed by osteotomes and bone cutters. Calcaneus was pushed

Table 1
Patients' characteristics.

Patient	Sex[a]	Age	Duration	Pedal pulses	Duration		Location of Charcot deformity				Comorbidities	Complications	Duration healing	Result	Duration of follow up	Neuropathy
			DM[a]	DP[a]/TP[a]	Charcot deformity	Wound infection	Mid foot	Hind foot	Fore foot	Malleol						
1	F	44	11 y	+/+	4 y	2 y	–	+	–	–	Calcaneal fracture	–	3 m	Successful	4 y	Severe
2	M	54	15 y	+/+	1.5 y	6 m	+	+	–	–	None	–	3 m	Successful	4 m	Severe
3	M	60	21 y	+/–	1 y	10 m	+	+	–	–	None	–	4 m	Successful	2.2 y	Severe
4	M	68	13 y	+/+	1.5 y	1.5 y	+	+	–	+	Calcaneal fracture	–	4 m	Successful	2.1 y	Severe
5	F	64	16 y	+/+	1 y	1 y	+	+	+	–	None	–	4 m	Successful	1.5 y	Severe
6	M	35	15 y	+/+	4 y	4 y	+	+	+	+	Calcaneal fracture	–	4 m	Successful	3 y	Severe
7	F	40	12 y	+/+	4.5 y	4.5 y	+	+	+	+	None	–	4 m	Successful	1.5 y	Severe
8	F	59	20 y	+/+	8 m	8 m	+	+	–	+	None	–	3.5 m	Successful	7 m	Severe
9	M	58	25 y	+/–	5 y	5 y	+	+	–	–	Chronic renal failure	–	6 m	Successful	6 m	Severe
10	F	41	20 y	+/+	7 m	7 m	+	+	+	+	Calcaneal fracture	–	3.5 m	Successful	2 y	Severe
11	F	66	25 y	+/+	1 y	2.5 y	+	+	+	+	None	–	3.9 m	Successful	2.5 y	Severe

[a] DM, diabetes mellitus; F, female; M, male; TP, posterior tibial artery; DP, dorsal artery of the foot; y, years; m, months.

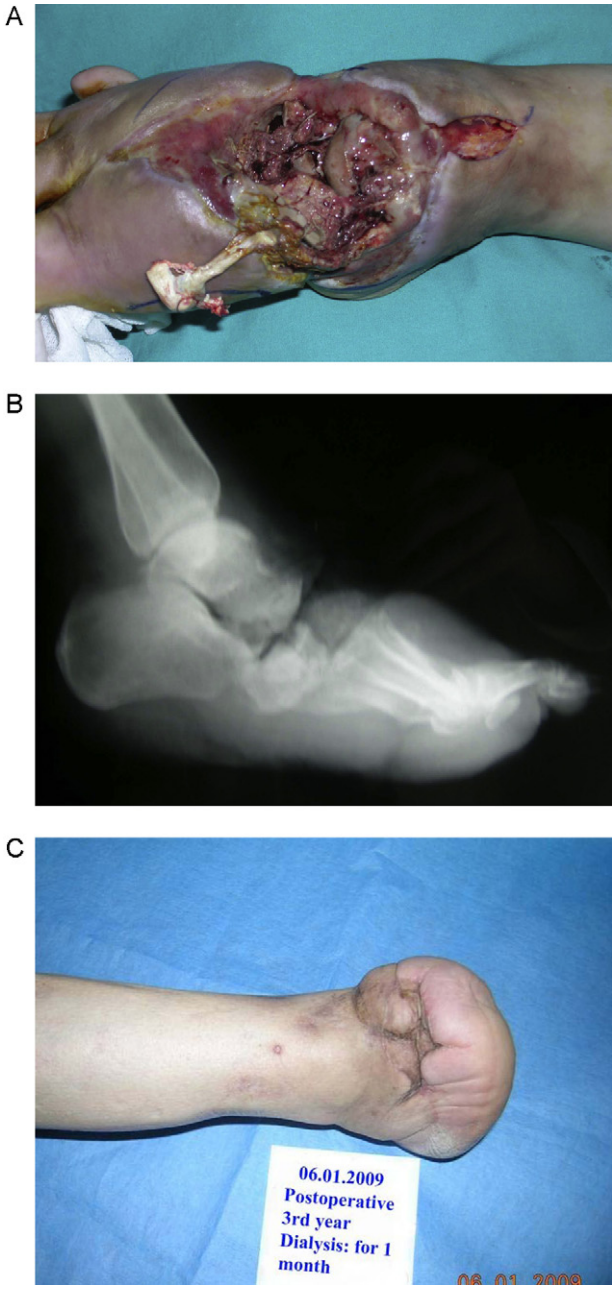

Fig. 2. (A) A 41-year-old female patient with history of Type I DM for 20 years has a large infected open wound on the dorsum of her right foot for last 7 months. (B) Plain radiographs of the foot demonstrated severe destruction of midfoot bones. (C) Late result.

forward and fixed to the tibia with 2–3 Kirschner wires without leaving a dead space between them. The arthrodesis site was then covered by the muscular parts of the flaps. A wet sponge was applied over the muscle flaps. Plantar and dorsal flaps were brought together in an anatomical fashion so as to cover the dressings, and the wound was left open. After the first stage of the operation, local wound care was undertaken with regular and daily wet-to-wet dressings. About 2–3 weeks after the first stage, in the second stage, the flaps were sutured to each other. It is very important to leave sufficient skin flaps to cover the stump primarily. However, if there is a tension on stump, a small split thickness skin graft may be used to provide appropriate primary healing conditions. The foot was supported with a half cast. When the amputation stump was healed without a complication, a total contact cast was prepared to support further bone fusion. Patients were allowed to walk with the cast 2 months after the second operation and without the cast after another 15 days.

2.3. Case reports

Case 1. A 41-year-old female patient with a history of DM for 20 years admitted to us with complaints of having a large infected open wound on the dorsum of her right foot for last 7 months. She claimed that before this, she had swelling and deformation of her foot for last 2 years. Local physical exam revealed that she has a large infected open wound with exposed tarsal bones on the dorsum of her right foot. X-ray shows multiple fractures and

Fig. 3. (A) A 68-year-old male patient with history of Type 2 DM for 13 years. There is severe swelling, inflammation and fistula orifices at the hindfoot. (B) Plain radiographs revealed destruction of bones and calcaneal fracture. (C) Postoperative 24th months.

destruction of tarsal bones (Fig. 2A and B). After an interval period of wound care and appropriate antibiotherapy, first stage of Boyd's operation was undertaken. A successful partial foot amputation, talectomy with resection of the all articular cartilages was carried out preserving adequate dorsal and plantar skin flaps. The operation was terminated at this stage since clinical perioperative observation revealed that there was a high probability of infection. After a open wound care period of 2–3 weeks, a healthy granulation tissue formed on the wound surface. In the second stage, tibiocalcaneal arthrodesis was performed first, then stump was closed in layers with dorsal and plantar skin flaps. Since we could not close the stump with dorsal and plantar flaps alone without tension, we used a split thickness skin graft for closure (Fig. 2C).

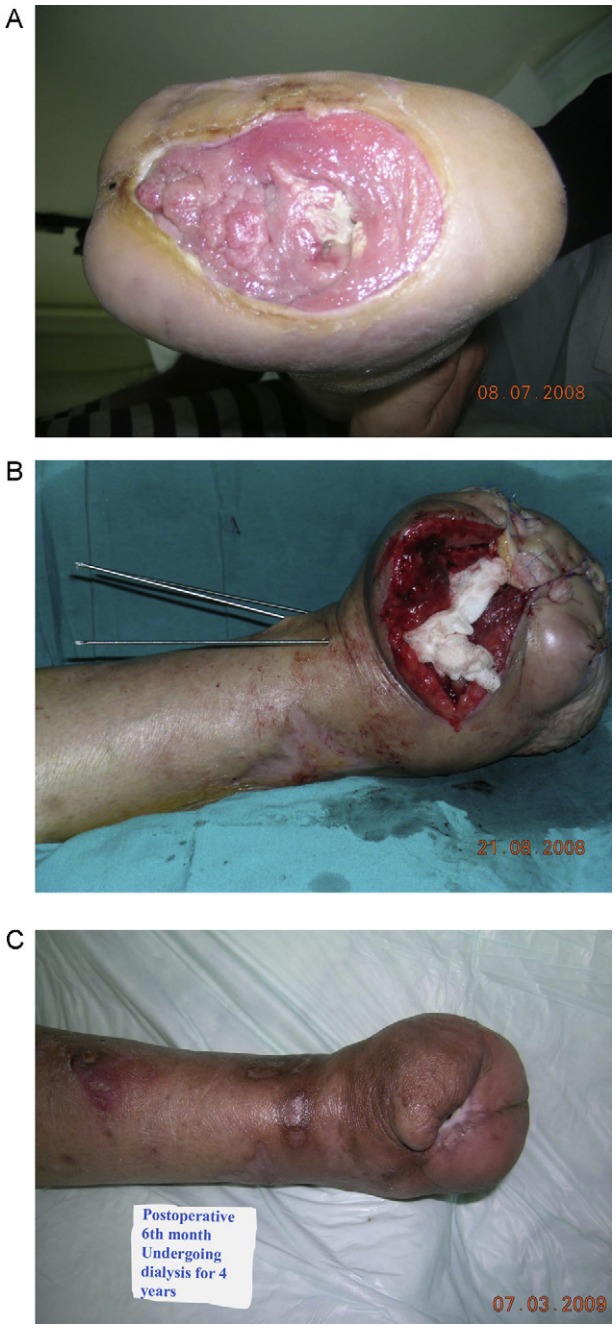

Fig. 4. (A) A 58-year-old male patient with a history of DM for 25 years has a large deep ulcer on sole of the foot. (B) Following talectomy and resection of the articular surfaces, tibiocalcaneal arthrodesis was performed using K wires. (C) At postoperative 6th month complete healing was achieved by secondary healing.

Case 2. A 68-year-old male patient with a history of DM for 13 years had complaints of swelling and bad smelling discharge from his left foot which were present for 1.5 years. Physical exam revealed few fistulae orifices in the hindfoot and multiple fractures and destruction of tarsal bones (Fig. 3A and B). After hospitalization, fistulae orifices were dilated carefully and abscesses were drained. After about one week of open wound care with serial dressing changes, first stage of Boyd's operation was performed. Partial foot amputation involving the forefoot and midfoot regions, talectomy, resection of the articular surfaces and tibiocalcaneal arthrodesis with Kirschner wires were performed in the first stage. After 2 weeks of interval period, the stump wound was closed secondarily in the second stage (Fig. 3C).

Case 3. A 58-year-old male patient with history of DM for 25 years and dialysis for 4 years was seen in our clinic. He claimed that he had swelling and deformation of his right foot for last 6 years. Physical exam revealed a large and deep ulcer on the sole of the foot (Fig. 4A). Talectomy and resection of the articular surfaces were performed first followed by tibiocalcaneal arthrodesis using 3 Kirschner wires (Fig. 4B). After an interval period of 2 weeks, the stump was closed secondarily in the second stage. At postoperative 6th month complete healing was achieved (Fig. 4C).

3. Results

The total contact casting was removed in 10 patients after a mean period of 3.5 months. It was observed that stable wound healing had been achieved and edema of the soft tissues had regressed. After removal of the Kirschner wires, sufficient stability at the ankylosis site was observed. The patients were permitted to bear weight on the affected splinted limb in a controlled manner 15–30 days after removal of the K wires.

Wound healing and callus formation were delayed in one patient who had been undergoing chronic dialysis treatment. In this patient, it took about 6 months for complete healing during which wound care was done through a window on total contact cast.

All patients were able to walk by themselves with custom-made boots or special prostheses. No foot problem was observed in any of the patients during the mean post-operative follow-up period of 2.1 years.

4. Discussion

The main purpose for the treatment of diabetic patients with Charcot foot deformity should be preventing disruption of the foot's architecture which is designed for walking. In early stages of the deformity, total contact casting is necessary to stop progression of deformity.

In the end stage of the disease, foot ulcers, deformations, fractures and infections are common. For the treatment, generally surgical interventions such as exostectomy, osteotomy, arthrodesis, internal–external fixation, grafts, and flaps can be used [3–9]. However, ulcer recurrence and infections are very common following these surgical interventions [3,4,9,10].

Seventy percent of all Charcot foot deformities are confined to the midfoot [3]. In the midfoot, there are many small bones that are cubic in shape. These bones are arranged as keystones and have many joint surfaces. Many fibroreticular ligaments interconnects these bones. Furthermore most of these tissues are hypovascular and have poor regenerative capacity. They easily lose their viability in infected environment. Infection and necrosis can easily spread through these bradytrophic tissues, leading to progressive dislocations and new bone fractures resulting in complete collapse of the foot skeleton [1]. This leads to a stage in which the foot architecture cannot be reconstructed and widespread infection

and necrosis cannot be eradicated. For late stage Charcot foot, partial foot amputations (proximal) and/or transtibial amputation remain the only options for treatment.

It is quite interesting that there are only a few publications about partial foot amputation types in patients with diabetic foot problems [1,11–13]. Most of these publications are short case reports which provide quite limited information about techniques. Furthermore, there are some publications in which authors warn against the use of Chopart and Boyd's operations in diabetic foot patients [14].

In one of our previous publications, we highlighted limited use of Chopart operation in patients with diabetes mellitus [1]. In late stage Charcot foot deformity, there is extensive destruction, serious infection and necrosis which most of the time involves the talus and the malleoli. Therefore, we believe that Chopart amputation use is more restricted in these cases.

Technically, the Boyd's operation is more difficult than other midfoot and hindfoot amputations. However, the structure of foot after Boyd's operation has best functional late results in addition to having residual healthy tissue composition and good wound healing since all bradytrophic tissues were removed in this operation [1]. When it has an adequate length and thickness, the plantar flap can provide adequate soft tissue support. In addition, muscle tissues on plantar surface would cover the ankylosis zone, enhancing the process of healing.

Removal of the talus prevents the equinus deformity which results from the shortening of the Achilles tendon. Moreover, removal of the talus decreases the size of the amputation stump, providing easy and safe closure. The Boyd's operation results in about 4–5 cm shortness of the leg and ankylosis between calcaneus and tibia. We believe that decrease in the length and the ankylosis facilitate walking and increase the stability of the foot. When the healing process is completed, patients take a walk for short distances within the house with custom-made shoes. Boyd's operation obviates the problem of migration of the heel pad compared to Syme amputation, but a longer waiting period before prosthetic fitting is usually necessary, and the extra length of the residual limb can sometimes make prosthetic foot fitting difficult.

In more than 50% of our cases, the perioperative findings confirmed that infection and necrosis spreaded the tibiotalar and talocalcaneal joints. In these cases, it was evident that partial foot amputations at the level of the Chopart joint or distal to it would be unsuccessful. In 4 cases, multiple calcaneal fractures with total midfoot collapse were present. The cancellous structure of the calcaneus offers a distinctive advantage over the other bones in terms of fast healing. Removal of all articular surfaces provides a strong ankylosis between the tibia and the calcaneus.

The mean age of the patients with Charcot foot deformity in this study was 53.4 ± 10.2 years. This value is about 9 years lower than the study group that we published for 600 diabetic patients who had surgical treatment [15].

Vascularity of the involved extremity was checked with physical examination. In 9 patients (82%), both pedal pulses were palpable. In 2 patients, dorsalis pedis artery was palpable, but posterior tibial artery was non-palpable We believe that success rate of Boyd's operation in these group of patients is higher since not only the patients are younger and also they have better peripheral vascularity which provides better wound healing conditions.

5. Conclusion

Two-staged Boyd's operation in the treatment of late stage complicated Charcot foot deformity allows wound healing within 62 ± 12 days and enable walking with a custom-made boot or special prosthesis within 12 weeks.

References

[1] Altindas M, Kilic A. Is Boyd's operation a last solution that may prevent major amputations in diabetic foot patients? J Foot Ankle Surg 2008;47:307–12.
[2] Altindas M, Cinar C, Kilic A. A safe and physiologic method for a less bloody surgical field in diabetic foot surgery: elevation with the trapezoid pillow. J Foot Ankle Surg 2006;45:134–5.
[3] Sayner LR, Rosenblum BI. External fixation for Charcot foot reconstruction. Curr Surg 2005;62:618–23.
[4] Caravaggi C, Cimmino M, Caruso S, Dalla Noce S. Intramedullary compressive nail fixation for the treatment of severe Charcot deformity of the ankle and rear foot. J Foot Ankle Surg 2006;45:20–4.
[5] Hamilton GA, Ford LA, Perez H, Rush SM. Salvage of the neuropathic foot by using bone resection and tendon balancing: a retrospective review of 10 patients. J Foot Ankle Surg 2005;44:37–43.
[6] Simon SR, Tejwani SG, Wilson DL, Santner TJ, Denniston NL. Arthrodesis as an early alternative to nonoperative management of Charcot arthropathy of the diabetic foot. J Bone Joint Surg 2000;82:939–50.
[7] Sayner LR, Rosenblum BI, Giurini JM. Elective surgery of the diabetic foot. Clin Podiatr Med Surg 2003;20:783–92.
[8] Johnson JE. Operative treatment of neuropathic arthropathy of the foot and ankle. J Bone Joint Surg 1998;80:1700–9.
[9] Garapati R, Weinfeld SB. Complex reconstruction of the diabetic foot and ankle. Am J Surg 2004;187:81–6.
[10] Marks RM. Complications of foot and ankle surgery in patients with diabetes. Clin Orthop 2001;391:153–61.
[11] Frykberg RG, Abraham S, Tierney E, Hall J. Syme amputation for limb salvage: early experience with 26 cases. J Foot Ankle Surg 2007;46:93–100.
[12] DeGere MW, Grady JF. A modification of Chopart's amputation with ankle and subtalar arthrodesis by using an intramedullary nail. J Foot Ankle Surg 2005;44:281–6.
[13] Yoho RM, Wilson PK, Gerres JA, Freschi S. Chopart's amputation: a 10-year case study. J Foot Ankle Surg 2008;47:326–31.
[14] Smith DG. Amputation. Preoperative assessment and lower extremity surgical techniques. Foot Ankle Clin 2001;6:271–96.
[15] Altindas M, Kilic A, Cinar C, Bingol UA, Ozturk G. The epidemiology of foot wounds in patients with diabetes: a description of 600 consecutive patients in Turkey. J Foot Ankle Surg 2011;50:146–52.
[16] Boyd HB. Amputation of foot with calcaneotibial arthrodesis. J Bone Joint Surg 1939;21:997–1000.