A Modification of Chopart's Amputation With Ankle and Subtalar Arthrodesis by Using an Intramedullary Nail

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This study reports on 7 patients who underwent a new technique for Chopart amputation that includes ankle and subtalar arthrodesis using an intramedullary nail. This method affords rigid control to the rearfoot and appears to avoid the most common complications historically associated with Chopart amputations. All 6 surviving patients achieved successful outcomes within 1 year of their surgery. All are community ambulators who are able to walk short distances within the home without a prosthesis. One patient, who had undergone a previous vascular bypass, died in the early postoperative period after developing an infection that required an above-knee amputation. A second patient developed an infection that resolved with intravenous antibiotics. This new technique reintroduces the Chopart-level amputation as a valuable intermediate between the transmetatarsal and below-knee amputation levels.
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Francois Chopart first described disarticulation at the midtarsal joint in 1792 (1). Since that time, Chopart's amputation has generally been regarded as tenuous at best, and disastrous at worst (2–11). The reasons for this reputation are largely due to the equinovarus deformity that results if measures are not taken to prevent it (12–14). Diabetic and neuropathic patients undergoing a lower extremity amputation possess unique and more rigorous requirements for success than their nondiabetic, sensate counterparts. Young, healthy trauma victims have been reported to have excellent results after Chopart amputation because of the presence of a sensate foot (15, 16). Without intact sensation, recognizing increased plantar pressures from a progressive equinovarus deformity or a suboptimal prosthetic fit is difficult or impossible. Therefore, the patient with the insensate foot requires an operation that functionally reconstructs the foot and simultaneously prevents the deformity that most threatens it. "Functional" reconstruction can be defined as a stable, weight-bearing stump with maximal limb-length preservation.

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Techniques have been described for tibialis anterior or tibialis posterior tendon transfer to the talus to avoid the equinovarus complication (11, 15, 17–20). Persson and Soderberg described 2 cases of Chopart amputations further revised to include pantalar arthrodesis using staples (21). The senior author (J.F.G.) has devised a new way to combine the Chopart amputation with a pantalar fusion. The purpose of this report is to share our early experience of Chopart's amputation combined with ankle and subtalar arthrodesis using an intramedullary nail.

Materials and Methods

Between 1998 and 2002, 7 patients underwent the index procedure. Inclusion criteria were as follows: 1) functional loss of the foot distal to Chopart's joint but with a plantar flap of sufficient size for primary or delayed primary closure, and 2) adequate vascular status of the plantar flap and foot proximal to Chopart's joint. "Functional loss" of the distal foot was defined as the presence of 1 or more stagnant or severe conditions requiring amputation and/or precluding ambulation and not amenable to a more distal amputation level. These conditions included ischemia, gangrene, infection, ulceration, failure of previous distal amputation, trauma, osteomyelitis, and Charcot neuroarthropathy. "Adequate vascular status" was defined as: 1) a palpable dorsalis pedis and/or posterior tibial pulse with at least 1 biphasic Doppler signal, and 2) capillary return to the plantar flap of 3 seconds or less after blanching on palpation or diascopy. In cases in which vascular status was equivocal, a

FIGURE 1 Chopart amputation of a right foot with a long plantar flap, as seen from above.

preoperative evaluation was also performed by a vascular surgeon. In those cases, the decision to proceed was based on the vascular surgeon's final analysis that vascular perfusion was adequate.

Exclusion criteria included: 1) medical frailty, defined as a patient's inability to safely undergo general anesthesia; 2) severe anemia, defined as a hemoglobin value of less than 10 g/dL; and 3) nonambulatory status that would never change, regardless of procedure.

Success was defined by a patient exhibiting 2 characteristics within 1 year of the surgery: 1) an uninfected, wound-free residual foot; and 2) the ability to bear weight and ambulate at least short distances within the home on the operated foot either with or without the aid of a prosthesis. Failure was defined by either of the following: 1) the development of an equinovarus deformity on the operated foot, or 2) the need for more proximal ipsilateral amputation. These criteria were determined at the time of the latest postoperative follow-up.

The senior author (J.F.G.) was present for each preoperative evaluation, directed the operations, and directed the postoperative care of every patient in this study. Follow-up was coordinated in the VA hospital clinic or private office, depending on the origination of the particular patient.

Surgical Technique

In the presence of acute infection to the distal portion of the foot, a staged operation was performed. Distal open amputation with resection of all necrotic material, followed by an appropriate course of parenteral antibiotics, was undertaken first. Once evidence of infection resolved, the second stage of Chopart amputation with intramedullary nail fixation was performed.

To perform the Chopart amputation, a dorsal incision was made over the midtarsal joint, and the medial and lateral extents of this incision were carried distally as far as possible to create a full-thickness plantar flap (Fig 1). Redundant tendons were placed under traction and divided at a proximal location within the surgical field. Prominences of the talar head and the anterior process of the calcaneus were reduced to avoid pressure areas after closure. The articular cartilage in nonprominent areas was preserved as a physiologic cap to the distal amputation site.

The ankle and subtalar joint surfaces were then denuded of articular cartilage in preparation for arthrodesis. Intraoperative fluoroscopy was used to assess the position for optimal tibiotalar and talocalcaneal fixation. The foot was positioned with the subtalar joint in 0°–5° valgus and the ankle joint in neutral dorsiflexion. To achieve this, percutaneous hemisection or transection of the Achilles tendon was usually necessary, and usually performed early in the operation. The intramedullary nail was then inserted using the technique specific to the type of nail selected. Final fluoroscopic views were taken, and the incision and flap were closed in layers. Redundant flap may be trimmed, but care should be taken so the incision is closed without tension. A drain was often placed laterally in the wound, and a compression dressing was applied.

The patient was maintained nonweightbearing on the operative foot for the first 6 weeks. If adequate radiographic healing and maturation of the stump were realized at that time, partial weightbearing was allowed in a cast with an appropriate gait-assistive device for approximately 3 weeks.

FIGURE 2 *(A)* Early postoperative anterior-posterior radiograph of a right foot after completed amputation (skin staples present). *(B)* Six-week postoperative lateral radiograph of a right foot after completed amputation (autogenous bone graft seen at anterior ankle joint). *(C)* Mortise radiograph 2 years after index surgery. Note solid fusion and axial alignment of the calcaneus. *(D)* Lateral view of same patient, 2 years postoperative.

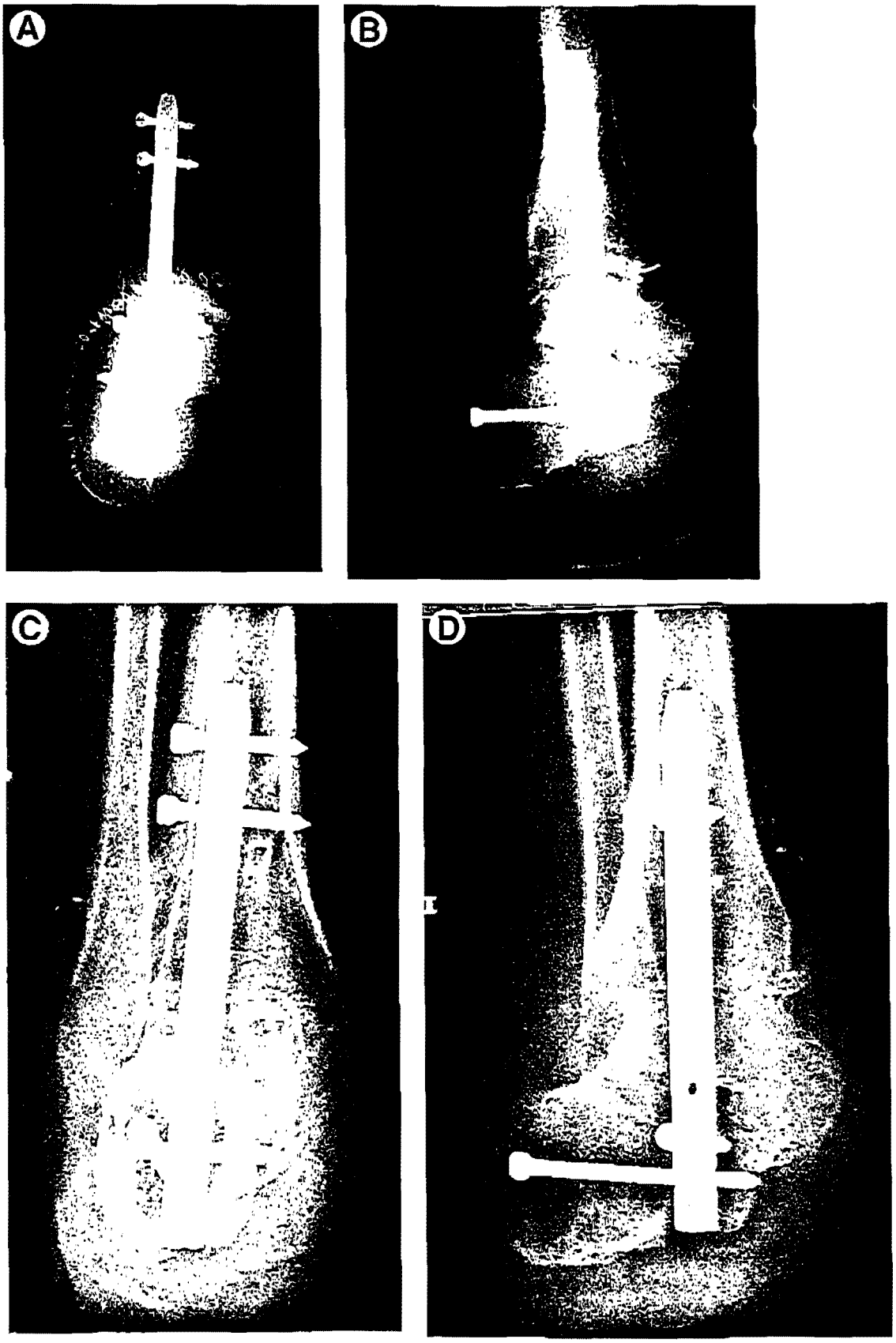
A
B
C
D

TABLE 1 Patient Data

Patient Number	Age	Reason for Chopart Amputation	Months of Follow-up
1	78	Diabetic peripheral neuropathy with forefoot osteomyelitis	56
2	41	Alcoholic peripheral neuropathy with forefoot osteomyelitis	37
3	60	Diabetic peripheral neuropathy with forefoot gangrene	32
4	47	Charcot neuroarthropathy with midfoot osteomyelitis	30
5	80	Diabetic peripheral neuropathy with forefoot osteomyelitis	Death after AKA surgery, 1 month following amputation
6	45	Diabetic peripheral neuropathy, gangrene with osteomyelitis	16
7	64	Diabetic peripheral neuropathy, cuboid-fifth metatarsal osteomyelitis	10

Postoperative weeks 9–12 allow a transition to full weight-bearing in a cast, though a gait-assistive device was often still needed for stability until a formal prosthesis was fabricated. Prosthesis casting and fitting occurred after the third postoperative month, when clinical and radiographic fusion was confirmed and residual edema had receded. Ambulation to tolerance in either a clamshell or patellar tendon-bearing prosthesis was the most common scenario. Serial radiographs were taken throughout the postoperative period (Fig 2).

Results

Demographic specifics are given in Table 1. Patients ranged in age from 41 to 80 years. Although men and women were equally accepted, this study was exclusively among men, owing to the majority of male patients in the Veterans Affairs medical center. Follow-up ranged from 10 months to 4.7 years.

One case resulted in death within the first postoperative month. The patient's preamputation diagnoses included diabetes mellitus with peripheral neuropathy and peripheral vascular disease and osteomyelitis; he had also undergone previous vascular bypass. Overwhelming infection in the postoperative period necessitated above-knee amputation, and the patient succumbed to cardiac complications shortly thereafter.

The most recent patient in this series had a postoperative complication of prolonged methicillin-resistant *Staphylococcus aureus* (MRSA) infection, which resolved after 3 months of intravenous vancomycin.

Among the 6 survivors, all patients achieved successful outcomes within 1 year of their operation. At the time of writing, all were community ambulators, 4 patients used a patellar tendon-bearing prosthesis, 1 used a clamshell type of prosthesis and 1 ambulated in a modified cast boot. None required a prosthesis to ambulate without pain for short distances such as from room to room within the home. None have reulcerated or broken down their stump, and rigid internal fixation without equinovarus deformity has been maintained. The clinical results of a patient after a 2-year follow-up are depicted in Fig 3.

Discussion

Following amputation through the calcaneocuboid and talonavicular articulations (Chopart's joint), there exists an inherent muscular imbalance to the residual foot. With an unopposed Achilles tendon, an eventual equinovarus attitude of the hindfoot is likely; when it occurs, breakdown of the stump is imminent regardless of the type of prosthesis. This was the basis for historical accounts that doomed the Chopart amputation to universal failure (2–6, 11). In contrast, pantalar fusion after Chopart amputation negates the function of the Achilles tendon. Therefore, Achilles hemisection or transection has the benefit of permitting proper positioning of the rearfoot for fusion, while making Achilles overlengthening complications moot.

The procedure described in this paper also has the advantage of maintaining a nearly full-length limb. Several investigators have reported the benefits of this type of length preservation (12, 13, 19). Once the healing process is completed, this operation allows patients to take short trips from room to room within the home without a prosthesis. Maintaining an adequate amount of plantar flap is critical to long-term success. This flap will cover the plantar, anterior, and part of the superior surface after the surgery, and it will provide the hardiest protection for the foot in a prosthesis. The added resilience of this specialized tissue is particularly valuable to the neuropathic patient.

Several published studies suggest that the energy demands for ambulation are increased with ascending levels of amputation of the lower extremity (22–24). Furthermore, the energy consumption and mortality data for below-knee and above-knee amputations are strong motivators to consider them only as a last resort (25–28). Therefore, choosing the most distal amputation level possible that gives the patient a functional result is an important dimension in limb salvage surgery. When a transmetatarsal amputation is not possible and a Syme or Boyd amputation is more proximal

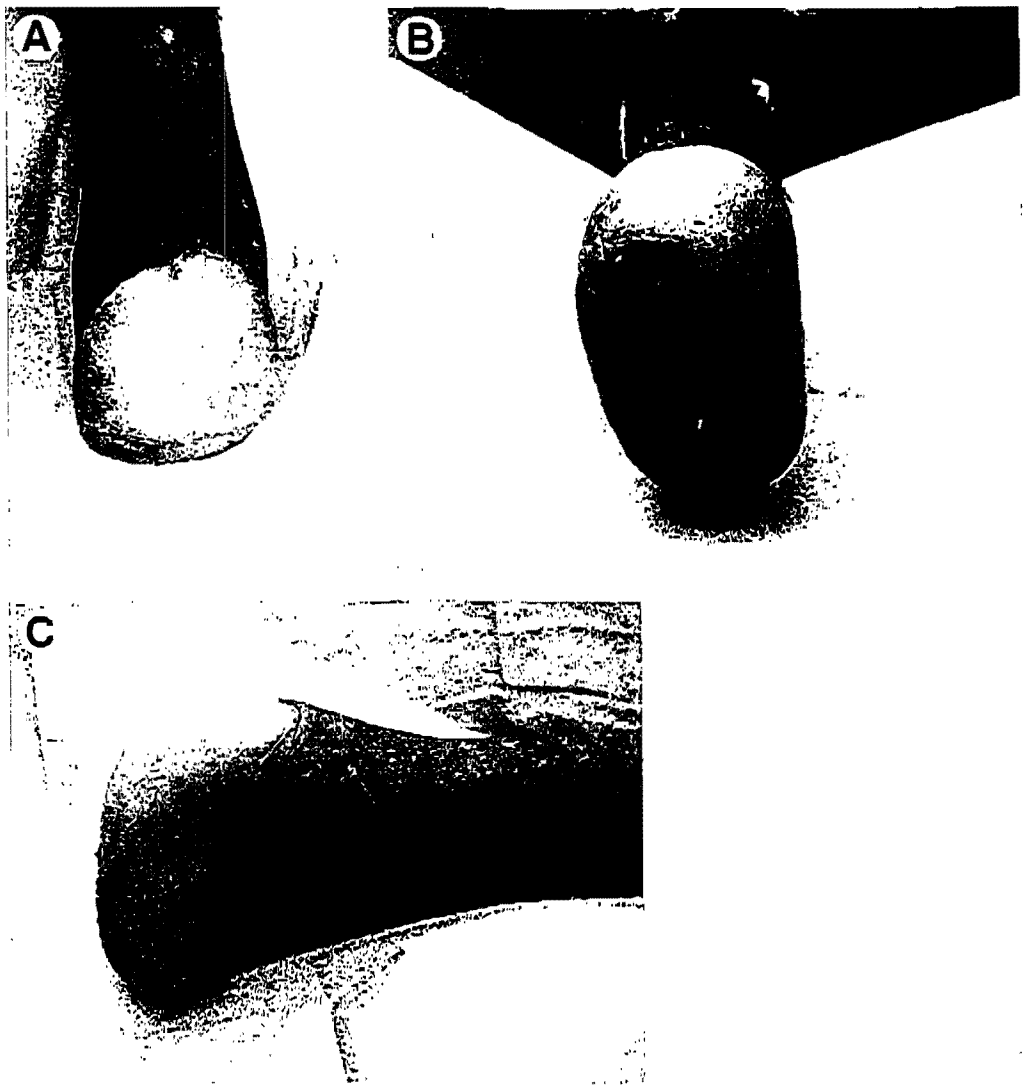

FIGURE 3 Clinical appearance of right foot after amputation. *(A)* Anterior view. *(B)* Inferior view. *(C)* Medial view.

than necessary, the Chopart amputation merits consideration.

This study's sample size was relatively small, which limits the interpretation of its data. However, a small sample size is understandable, even from a vast surgical patient base over several years. This is because precisely the right anatomic geography must be present for the Chopart amputation to be a tenable option. Within the niche of patients with forefoot loss, a salvageable talus and calcaneus, adequate plantar flap, and good vascular perfusion, the Chopart amputation may be the most distal, functional level.

One patient in this series died as a result of complications after the operation. This same patient had peripheral vascular disease that required revascularization prior to the Chopart amputation. It could be argued that patients in the dysvascular category possess a relative contraindication for this operation. However, it could also be argued that these patients are otherwise doomed with a functionless limb or impossibly high metabolic costs for ambulating if higher-level amputation is undertaken. Studies with larger sample sizes are needed to further explore these topics.

Conclusion

The Chopart amputation does not replace distal amputation levels when they are appropriate, nor is it a universal substitute for below-knee or Syme amputation. Of note, James Syme himself regarded the Chopart amputation as "the most valuable of all partial amputations" (19). Future studies with larger sample sizes, longer-term follow-up, energy consumption data, and mortality statistics specific to

Chopart-level amputation are all worthwhile endeavors that would further define the full benefits of this procedure.

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