CHAPTER **40**

EXTERNAL FIXATION AND CHARCOT: Results

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Charcot neuroarthropathy can be a crippling condition, leading to the rapid onset of painless destruction of the normal bony architecture in the lower extremity. These patients often present with a number of other comorbid conditions. Our goal for these patients is multifold. First the goal is to halt the progression of the Charcot breakdown process. Second is to provide a stable plantargrade foot that is adequate for ambulation. Third is to prevent complications associated with non-weightbearing such as contralateral breakdown. And last, to minimize the operative time during the reconstruction process.

Protection of the involved extremity from destructive forces is crucial in order to allow the healing process to occur. An Ilizarov external fixator (Ex-fix) after the reconstruction process allows for the patient to weight bear much sooner (often immediately) after surgery. The fixator acts as an "External cast" so that consolidation can take place while the patient remains ambulatory. Thus, the contralateral limb is not placed under the increased stresses, which occur when a patient is ambulating with crutches.

Early surgical intervention allows for the ability to halt the progression of breakdown before more deformity occurs. The senior author recommends a stabilization procedure in order to halt the progression of the Charcot breakdown. In the absence of gross deformity with plantar prominences, severe transverse plane deformity, or an uncompensated varus or valgus position of the forefoot, the goal is to simply halt the progression of the breakdown. With Stage I – III Charcot, consolidation will occur, allowing for stabilization, if the joints can be shielded from bending forces. Percutaneous cannulated screws are placed across the fragmented joint(s) and other neighboring joints for stabilization. Although these are not true fusions, an extra-articular fusion often occurs as the fragmented joints consolidate.

If prominent exostoses are present, they are removed until they are no longer prominent and planar with the weight-bearing surface. If gross breakdown has occurred and the current position is unsatisfactory, a realignment arthrodesis is necessary. Midfoot deformity is corrected in the form of a modified Cole-type midfoot osteotomy and wedged appropriately to correct the deformity. Any exostoses or bony debris are removed in order to give a more anatomic contour to the foot. An Ilizarov external fixator is then placed on the foot to neutralize any bending forces across the stabilized or arthrodesed joints.

If the position of the rear foot is unacceptable, a realignment arthrodesis is done to place the rear foot in the appropriate position. The joints are then pinned with either Stienmann pins or K-wires before the Ilizarov frame is placed. When severe degeneration of the talus and rear foot complex are present, a tibiocalcaneal arthrodesis is performed. After extirpating the talar fragments, the distal tibia is fashioned to be placed in a notch in the calcaneus. All cartilage on the calcaneal portion of the subtalar joint is removed, and a corresponding notch on the calcaneus is fashioned to the distal tibia. Cartilagenous surfaces are also resected at the calcaneocuboid joint and base of the navicular in preparation for fusion. An implantable bone stimulator is often placed, with the wire coil placed in the arthrodesis site(s). Autogenous bone graft is placed in and around each arthrodesis site, and the calcaneus is temporarily held in position with Steinmann pins. The naviculotibial and calcaneocuboid joints are also pinned with either Steinmann pins or K-wires. The Ilizarov frame is then applied and compressed across the arthrodeses sites.

MATERIALS AND METHODS

Twenty-four patients were identified who had undergone Charcot reconstruction using Ilizarov external fixation at our hospital since 1997. There were 10 males and 14 females with a total of 27 feet. A retrospective study was performed by 1) gathering data from the medical records, including history and physical, operative reports, discharge

summaries, and progress notes, and; 2) a telephone interview of each patient, or family member if the patient is deceased. The information was then compiled and analyzed.

The following data was gathered: 1) Age and sex; 2) Medical conditions present at initial presentation; 3) Whether ulcers were present at the initial surgery, and if so, what grade? 4) Where was the location of the Charcot breakdown? Were any other diagnoses present? 5) Was there a precipitating traumatic event? 6) Was there any previous treatment prior to the reconstruction? 7) What was the weight bearing status upon discharge from the hospital? 8) What was the method of surgical reconstruction? 9) What was final result, and how long did it take to achieve the final result? 10) Were there any postoperative complications or long term complications? 11) Was there any contralateral breakdown or complications? 12) What is the current ambulatory status, or what was ambulatory status at death? 13) What is the duration of follow up (months)? and 14) Would you undergo the surgery again?

RESULTS

The average age was 53.6 years (range 7-77 years) with a mean and mode of 56 years. The average number of diagnoses per patient was 3.6. Insulin dependent diabetes was the most common diagnosis associated with the Charcot breakdown in 62.5% of patients. Non-insulin dependent diabetes was associated with the Charcot process in 29.17% of the patients. One patient (4.17%) was diagnosed with congenital insensitivity to pain with anhydrosis (CIPA). Other co-morbid conditions included: hypertension (13); morbid obesity (6); CAD (5); status post CABG (4); anxiety or depression (4); kidney failure on dialysis (3); hypercholesterolemia (3); hiatal hernia or GERD (3); hypothyroidism (2); asthma (2); anemia (2); osteoporosis (2); congestive heart failure (1); COPD (1); fibromyalgia (1); gastroparesis (1); retinopathy (1); status post kidney transplant on immunosuppression (1); end-stage renal disease status post failed kidney transplant (1); status post double organ transplant (kidney and pancreas) on immunosuppression (1); status post myocardial infarction (1); gastric ulcers (1); renal insufficiency (1); epilepsy with seizures (1); stroke (1), and; contralateral below-knee amputation (1).

Seven grade I ulcers were present preoperatively. The tarsometatarsal joint (14) and ankle joints (14) were the most common sites of breakdown. Both were seen in 22.6% of the patients. The midtarsal joints (9) and subtalar joint (9) each were the site of breakdown in 14.5% of patients. Equinus (17) was a component in 63% of the feet. A dislocated non-union of the ankle joint (3) occurred in 4.8% of patients. Avascular necrosis or resorption of the talus (2) was found in 3.2%. Forefoot derangement (2) was present in 3.2% of patients as well. There was one fibular non-union and one severe pes planovalgus, each accounting for 1.64% of the diagnoses. A known precipitating traumatic event (9) occurred in 45% of those available at follow-up.

Sixteen patients (66.7%) had undergone previous treatment prior to surgery. The most common modality utilized was a non-weightbearing cast (8). Other modalities included: digital amputations (6); previous incision and drainage (4); ankle foot orthoses (3); total contact cast (3); local wound care with debridement (2); ORIF of the ankle (2); patellar tendon bearing brace (2), orthotics (1); CROW walker (1); shoe gear changes (1); hospitalization with IV antibiotics (1); oral antibiotics (1); whirlpool therapy (1); previous first metatarsal-cuneiform fusion (1); ORIF of calcaneus (1); external bone stimulator (1); cam walker (1); anti-depressant medication (1); and removable cast boot (1).

The weight bearing status of patients on discharge was either full weightbearing, parital weightbearing with ambulatory aids, or non-weightbearing. Full weight bearing (14) was allowed in 48.3% of the patients. Partial weight bearing with an ambulatory aid (8) was allowed in 27.6% of patients. Non -weight bearing (7) was the ambulatory status in 24.1% of patients on discharge for the following reasons: revisional ankle fusion (2), plantar ulcer on heel (1), recent contralateral hip dislocation (1), inability to coordinate with physical therapy (1), and placement in a long term acute care facility (1).

Percutaneous stabilization procedures were performed on 13 patients, including 16 feet, with 3 bilateral cases. A total of 51 joints were stabilized percutaneously across deformed charcot joints stage I-III. Joints stabilized included: Lisfrancs (12); medial column, including 1st metatarsal cuneiform, and naviculocuneiform joints (12); intercuneiform joints (1); subtalar joint (11); talonavicular joint (12), and; calcaneucuboid joint (11). The average time to final

result was 8.17 weeks. Successful stabilization consisting of a stable functional foot (10) was noted in 83.3% of patients. Poor results with percutaneous stabilization were noted in 16.7% of patients (2). One patient (case 15) broke his frame at 3 weeks and it had to be removed. He currently has a stable foot, which is in a varus attitude that requires an AFO for ambulation. Another patient (case 23) developed a stable foot at Lisfranc's joint, however the original rockerbottom deformity was captured in the stabilization. She also developed a "non-union" at the cuneonavicular and talonavicular joints with painful motion as a result of stabilizing across joints that had not fully developed a Charcot deformity. This required a revisional surgery, and the patient is presently in a frame.

There were 9 attempted ankle fusions in 6 patients in this series. Realignment arthrodeses (6) in dislocated charcot ankle joints achieved complete fusion in 83.3% of patients at an average of 14 weeks (range 8 – 18 weeks). One individual (case 8) underwent bilateral ankle fusions; the right healed uneventfully, however the left developed a Charcot breakdown and went on to non-union. The left ankle required two additional surgeries before fusion was achieved. The first revisional ankle fusion utilized a Richards revision retrograde nail, which went on to Charcot breakdown resulting in a non-union. Final fusion was obtained after a revisional realignment ankle arthrodesis was performed with the use of autogenous bone graft and an implantable bone stimulator. There were 2 arthroscopic ankle fusions, which resulted in complete fusion in 100%. One healed in 8 weeks, the other in 6 weeks. A Richards retrograde revision nail was utilized in the ankle, which healed in 6 weeks.

There were 2 attempted pantalar fusions in 2 patients in this series. Fusion was obtained in 1 patient (50%) at 12 weeks. The other patient (case 16) developed a Charcot breakdown while in the frame resulting in a non-union with resorption of the talus. He achieved complete fusion after a talectomy and tibiocalcaneal fusion with autogenous bone graft and implantation of an internal bone stimulator. Complete consolidation occurred in 10 weeks.

There was one Choparts fusion, which achieved full fusion 100% in 6 weeks. One patient (case 23) required a talonavicular and cuneonavicular fusion as a result of a painful "non-union" across previously stabilized joints.

There were 5 talectomies with tibiocalcaneal fusions with in this series. Complete fusion was obtained in 4 patients (80%) at an average of 16.5 weeks (range 10-24 weeks). One patient (case 19) developed a stable pseudo arthrosis (20%) at 16 weeks, which currently allows for ambulation in a protective brace. Another patient (case 17) achieved full fusion in 12 weeks; however, 6 months later developed another Charcot breakdown at the fusion site while walking barefoot at home. His current ambulatory status is FWB with an AFO in tennis shoes.

There were 3 realignment triple arthrodeses. 100% went on to full fusion. One patient (case 15) healed in 6 weeks with no complications. Another patient (case 18) went on to full fusion, however required 24 weeks. This patient was 415 pounds and broke the frame at 4 weeks post-op, which necessitated the early removal of the frame. Complete fusion was obtained after another 5 months in a NWB cast. The last patient (case 21) went on to full fusion at the time of frame removal. She was a referral from out of town and another doctor did the follow up care. Consequently not all of the information was available concerning her postoperative course.

There were 2 forefoot procedures performed. Both were performed in the same patient (case 11) along with other reconstructive procedures. The patient underwent a Mayo-Keller, excision of an ulcer, and a second metatarsal head resection. Five and a half months after the original reconstruction, the patient suffered a Charcot breakdown of her ankle, which required an additional surgery.

The Achilles tendon was noted to be a deforming force in 17 feet (63%). Each patient underwent a percutaneus tendoachilles lengthening procedure in conjunction with the other reconstructive procedures. There were 32 Ilizarov frames placed on 27 feet in 24 patients. The frames were utilized for both compression across the reconstructed areas as well as protection against disruptive forces that could further the Charcot deformity.

There were 3 grade I ulcers excised at the time of surgery. One patient (case 20) presented with an ulcer plantar to the calcaneocuboid joint. She later developed a post-operative infection requiring removal of the frame, multiple surgeries, and a cuboidectomy. Two exostectomies were performed, one in the previously mentioned patient under the cuboid, and another over the medial tarsometatarsal area (case 23) of the foot.

One revisional Cole type osteotomy (case 23) was performed at the Lisfranc's area. The patient had undergone a percutaneous stabilization, which resulted in a stable Lisfranc's, however, the original rockerbottom deformity was not corrected. She also developed a painful "non-union" at the cuneonavicular and talonavicular joints.

There were 23 complications reported which were divided into major and minor complications. There were 9 minor complications including: need to remove internal fixation (2); stiff foot (2); shortened leg (2); limp (1); swelling of foot (1); and ulcer still present (1).

There were 12 major complications in 9 separate patients. One patient (case 8) developed two Charcot breakdowns at the left ankle, which resulted in 2 consecutive non-unions. His ankle finally fused after two revisional ankle fusions.

One patient (case 11) developed a Charcot breakdown of her ankle 5 ½ months after her original reconstruction. This required an ankle fusion, which fused completely in 6 weeks.

One patient (case 15) had two major complications. The first resulted from a broken frame 3 weeks after his original reconstruction. The frame had to be removed and he was placed NWB. He placed weight on the foot while it was healing which resulted in a varus deformity in his left rear foot, and now requires an AFO for ambulation.

Another patient (case 18) also broke his frame 4 weeks after a realignment triple arthrodesis. The frame had to be removed and he was placed NWB in a cast. He went on to complete fusion, however, this required 6 months.

One patient (case 17) suffered a Charcot breakdown at the site of his original tibiocalcaneal arthrodesis 6 months after he had completely fused. The patient was walking in the house barefoot at the time. He currently has a semi-stable fibrous pseudoarthrosis, which requires an AFO for ambulation.

One patient (case 19) had two major complications. She was originally placed NWB for 6 weeks as a result of a contralateral hip dislocation just prior to surgery. When she began ambulation at 6 weeks post op, she developed a closed tibial fracture just proximal to the superior most ring of the Ilizarov frame. This required a closed reduction with the application of another more proximal ring. She also developed a Charcot breakdown at the original tibiocalcaneal arthrodesis site. This necessitated an I&D, and removal of the bone stimulator due to her past history of a positive bone culture in the area. She went on to a stable pseudoarthrosis at the fusion site and is currently ambulating FWB with a brace. This patient also developed a mid-shaft tibial fracture on the contralateral limb during the recovery period. Her limb, which underwent the original reconstruction, is now the better of her legs.

One patient (case 20) who originally underwent a bilateral reconstruction developed a post-op infection 2 weeks after the initial surgery, which required the removal of both frames. Multiple incision and drainages, including a cuboidectomy and placement of antibiotic impregnated PMMA beads, were necessary for healing to occur. Both feet had healed completely allowing for FWB at 12 weeks from the original surgery.

One patient (case 23) who had originally undergone a stabilization procedure for Charcot breakdown at the tarsometatarsal joint and midfoot developed a painful "non-union" at the talonavicular and cuneonavicular joints. The rockerbottom deformity, which had developed from the original breakdown, was not corrected with the stabilization and although the tarsometatarsal joint was stable, it retained the rockerbottom deformity. She required a revisional arthrodesis at the talonavicular and cuneonavicular joints. A Cole type osteotomy was performed to correct the rockerbottom deformity. She is currently in a frame.

Contralateral breakdown (3) was noted in 15% of the patients available at interview. Eighty five percent of the patients in this series (17) had no breakdown in the contralateral limb. One patient (case 16) developed a small ulcer on his left foot while he had the frame on, which went on to heal uneventfully with local wound care. One patient (case 19) developed a midshaft tibial fracture on the contralateral limb. One patient (case 20) developed a post-op infection, which spread to the contralateral limb, which had been reconstructed at the same time. This required the removal of both frames and multiple debridements before resolution of the infection and consolidation occurred.

Current ambulatory status in 91.3% of the patients in this series is FWB. Currently 8 of the patients in this series are FWB in regular shoes (35%). Six patients are FWB with extra-depth or orthopedic shoes (26%). One patient also utilizes a cane for ambulation. Four patients are currently FWB with a brace (17.4%). Three patients were

FWB at the time of death (13%). One patient who had a contralateral BKA when the original reconstruction took place had undergone a BKA at follow-up. However, prior to this event she was using the limb for transfers. One patient had moved away and was not available for follow-up. Another had passed away and ambulatory status prior to death was not available.

The average duration of follow-up in this series is 32.9 months (range 2-53). The median is 34 months, and the mean is 27.5 months.

Patients were asked if they would undergo the treatment again. Ninety-four percent of the patients stated they would undergo the treatment again. 76.5% responded yes. 17.6% of the patients responded yes, with reservation; and, 5.9% responded no. The main reason for answering yes, with reservation was due to the shock of having an Ilizarov frame. The patient who answered no is not satisfied because he still has an ulcer on his plantar heel. He did, however, completely consolidate at the pantalar fusion site.

Five of the patients (20.8%) in our series were referred after a below knee amputation (BKA) had been recommended by another surgeon. One hundred percent of these patients achieved FWB capacity after reconstruction. Four of the patients are currently living. Three are ambulating FWB in regular or orthopedic shoes. One requires an AFO, however is able to ambulate. One patient has passed away, however, was FWB at time of death.

Four patients (16.7%) in our series had died. Three, according to their family members, were FWB at the time of death. No further information was available on the other patient.

DISCUSSION

Charcot reconstructive surgery can be extremely gratifying. The ability to carry on normal activities of daily living is often contingent on the ability to ambulate and utilize the affected limb. However, this is a difficult patient population to work with. Complications will arise when performing surgery in this group of individuals. It is crucial to be vigilant of the progress the patients are making during their recovery period. Five patients in our series developed further Charcot breakdown after the initial surgery. Two patients developed Charcot events during the recovery period, before healing had occurred. This resulted in two non-unions at the ankle arthrodesis site in one individual (case 8). Another patient (case 19) developed a Charcot breakdown in the region of the sinus tarsi after a tibiocalcaneal arthrodesis had been performed. This necessitated further surgery as well. Three of the patients developed a Charcot breakdown after they had completely healed the initial surgery. One patient (case 11) developed a Charcot breakdown, which become infected and led to a BKA. Another patient (case 17) had a Charcot breakdown at his tibiocalcaneal arthrodesis site 6 months after he had completely healed. At the time he was walking around the house bare-footed. He now has a fibrous pseudoarthrosis, which requires an AFO for ambulation. The last patient (case 16) developed a Charcot breakdown 6 months after full fusion of his pantalar arthrodesis. He required a talectomy, with a tibiocalcaneal arthrodesis. Just because a stable arthrodesis has occurred does not mean these patient does not need to be supported. The same factors, which were present at the initial Charcot presentation, are still there. They still are neuropathic, but now they have even less flexibility in the lower extremity to take up the stresses of ambulation. These patients may be placed in at least a rockerbottom shoe in order to reduce the peak bending forces, which go through the ankle, midfoot, and forefoot regions.

In our series, two patients required the removal of their frames early as a result of the frames breaking. Both of these patients were morbidly obese. The first patient (case 15) was 290 pounds and was 5'9" tall. Three weeks after the initial reconstruction, his frame had to be removed after he broke the wires supporting the foot and leg. He went on to heal in 6 weeks, however, after his frame was removed, he put weight on his foot which resulted in a varus attitude of the rear foot. Although his ambulatory status is FWB, he requires an AFO for stabilization. The other patient (case 18) weighed 415 pounds and was 6'6" tall. Four weeks after his initial reconstruction, he broke his frame, which required it to be removed. After frame removal, he was placed NWB in a cast. Although he healed completely, it required 6 months to complete consolidation. He is currently FWB with the use of a brace. In light of this information, we recommend using more wires to stabilize the foot and leg in an Ilizarov frame if the patients are obese in order to avoid this complication.

The original goal of halting the progression of

the Charcot process was successful in 83.3% of the stabilization procedures. With fragmentation in the region of a joint, an extra-articular fusion often occurs with percutaneous stabilization. While the majority of the patients in our series obtained a stable functional foot, there were two complications in this group. The patient (case 15) who broke his frame 3 weeks after it had been placed ended up with a malposition of his rear foot. This, however, is attributed to having placed weight on his foot after the frame was removed. Sufficient consolidation had not occurred to prevent his body weight from causing a varus position of the rear foot. The other patient (case 23) was also left with a less than desirable result. She initially presented with a mild rockerbottom deformity after having suffered a Charcot breakdown at the tarsometatarsal and midtarsal joints. The progression of the Charcot deformity was halted, however, the rockerbottom was still present after consolidation across the tarsometatarsal joint occurred. She also had minimal breakdown at the midtarsal and cuneonavicular joints on initial presentation. Thus, percutaneous stabilization across these joints resulted in a painful "non-union" across the talonavicular and cuneonavicular joints. While many Charcot patients are neuropathic enough that this would not have been painful, in this case, a revisional arthrodesis of these joints had to be performed. In cases where stabilization is desired across joints, which are only minimally deformed, a limited dowel type arthrodesis (45) may help prevent this type of complication. However, in the majority of patients with fragmentation at the joints, percutaneous fixation works well to halt the progression, and is not complicated. If the original position of the foot would allow for a stable plantargrade foot, a percutaneous stabilization procedure is very effective.

The prevention of contralateral breakdown is another goal when performing Charcot reconstructive surgery. Eighty-five percent of our patients did not develop any contralateral breakdown or complications during the postoperative period. This, in part, is a result of being able to place weight on the affected extremity which has the Ilizarov frame. Although gait is somewhat altered as a result of the frame, it is still less stressful on the contralateral limb than a scenario with strict NWB on the affected limb. One of the patients who developed a contralateral ulcer, healed with simple local wound care. One of the complications with a contralateral limb was the patient (case 20) who developed a post-operative infection. We considered this a contralateral complication because it is feasible that the infection started on one limb and spread to the contralateral limb. The patient did not, however, suffer complications as a result of increased stresses on the contralateral limb in the post-operative period. The last patient (case 19) who developed a mid-shaft tibial fracture on the contralateral leg, suffered from congenital insensitivity to pain with anhydrosis. The actual fracture occurred after the frame had been removed, while she was immobilized for another Charcot breakdown at the tibiocalcaneal arthrodesis site. This patient has suffered a multitude of orthopedic-type injuries as a result of her insensitivity to pain. She is currently 7 years old and is FWB with the use of a brace on the original breakdown. A below knee amputation had been recommended prior to the initial surgery. External fixation allowed sufficient shielding of forces across the arthrodesis site to allow for a stable pseudoarthrosis, which is functional.

Another goal was to limit the operative time. This is not a healthy patient population. The average number of co-morbidities in our series was 3.6 per patient. We also found that 4 of our patients (16.7%) had deceased at follow-up. Serious consideration should take place when contemplating an in depth anatomical Charcot reconstruction in these patients. If you can halt the progression of the deformity and provide a stable plantargrade foot, which will allow the patient to ambulate pain free with less work, this is desirable. Of the 4 patients who had passed away, 3 were FWB at the time of death. The goal is also to improve the quality of life of these individuals,

CONCLUSION

External fixation is a wonderful tool to utilize in this patient population. It is well tolerated, and helps to allow the patient to continue functioning weight bearing in the post-operative period. Because of the circular configuration, the Ilizarov external fixator is much more stable than a monolateral external fixator. Combined with realignment arthrodeses, and percutaneous stabilization, external fixation sufficiently neutralizes the forces, which would generally further the Charcot breakdown process. Percutaneous stabilization will often result in an extra-articular fusion across joints,

which have undergone Charcot breakdown. It should be noted, however, that the foot will maintain the shape that is has when you percutaneously fixate it. If adequate alignment or architecture of the foot is not present, a realignment arthrodesis will allow for a more acceptable position. In cases where stabilization is desired, in the absence of fragmentation, a limited dowel type fusion can help prevent the complication of non-union. Percutaneous stabilization and external fixation are valuable tools when reconstructing feet in this patient population.

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