Technical Note

Arthroscopic Releases and Hindfoot Fusion for Spastic Equinovarus Foot Deformities, An All-Inside Technique

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Abstract: Neurologic foot contractures pose a challenging situation for orthopaedic surgeons. These deformities are long-standing problems for patients with acute brain injuries, ultimately affecting their quality of life. We report our experience with using arthroscopic assisted, minimally invasive contracture tenotomies paired with a tibio-talo-calcaneal arthrodesis to achieve improved alignment and functional reconstruction of spastic equinovarus foot deformities.

Acute brain injuries (ABIs), most commonly anoxic brain injuries or traumatic brain injuries, affect more than 2 million patients per year in the United States.[1] These injuries are followed by complications including progressive stiffness, muscular imbalance, and development of rigid contractures in the upper and lower extremities.[2] Spastic equinovarus foot (SEF) deformities are the most common foot deformity seen in adults who have sustained an ABI. These patients are subject to pain, pressure sores, and decreased quality of life due to progressive weakness, spasticity, and deformity.[3]

To date, there are limited reports regarding minimally invasive techniques using arthroscopy to perform SEF corrections. Our aim is to illustrate a technique using arthroscopic-assisted, minimally invasive contracture release paired with tibio-talo-calcaneal (TTC) arthrodesis to achieve improved alignment and functional reconstruction of the SEF.

Surgical Technique (With Video Illustration)

Preoperative Planning

Office visits should include a history of present illness, review of conservative treatments, physical examination, preoperative screening, radiograph of affected foot/ankle, and documentation of clinical images. Advanced imaging is not typically indicated. It is important to discuss goals of care to understand the patient's function/ambulatory status at baseline.[4,5] This surgical technique is not used to increase the motion of the foot and ankle but to create a reliable limb for transfers and modest ambulation (Fig 1, Video 1).

Positioning, Prepping, and Draping

The patient is brought to the operating suite and anesthesia is administered while they are supine. Once the patient is asleep, a thigh tourniquet is applied and the patient is positioned prone on padded gel rolls. Upper-extremity contractures may also be present and care is taken accordingly. The patient is positioned with their feet hanging over the end of the table, with knees slightly flexed and legs resting on a small gel pad. A 4-inch silk tape is used to secure the nonoperative lower extremity to the operating table. Prepping and draping is then performed in the standard sterile fashion. Screens are positioned at eye level over the patient.

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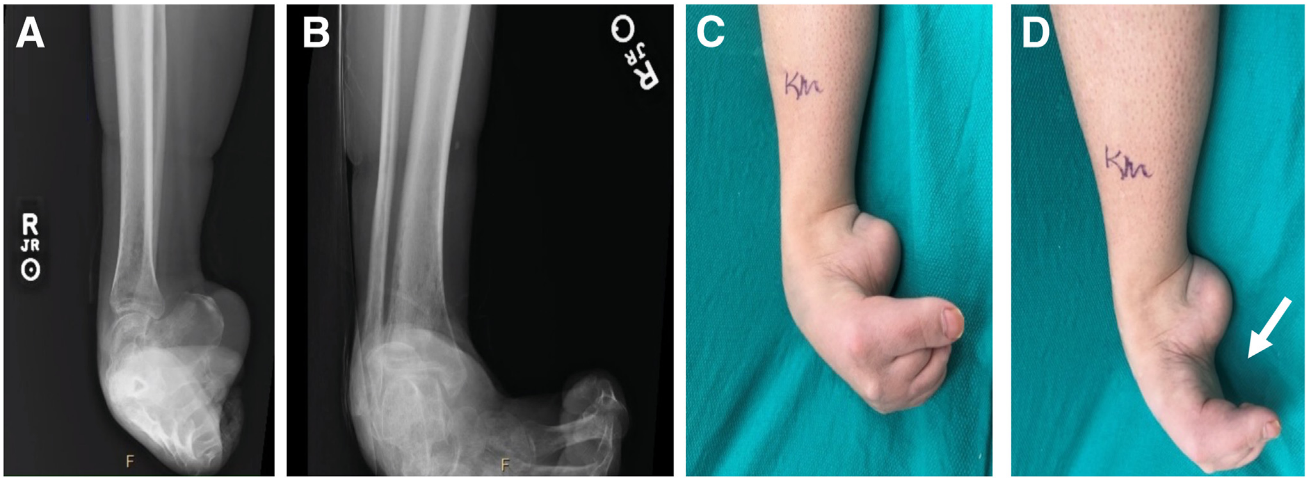

Fig 1. Right lower extremity in a patient positioned supine who experienced an anoxic brain injury. (A) Anteroposterior radiograph, (B) lateral radiograph, (C and D) clinical images. Note the characteristic "C" foot positioning (arrow) leading to skin and soft-tissue contractures.

Communication with the anesthesia staff helps to coordinate full paralysis during the case, allowing the surgeon to evaluate contractures and make adjustments to the surgical plan as needed (Fig 2).

Fig 2. Preferred positioning for prone ankle arthroscopy: 2 gel bumps underneath patient's shoulders to pelvis leaving room for the abdomen, yellow foam padding under knees and bony prominences, gel bump under operative ankle, ankles hanging in a neutral position off edge of bed. This demonstrates the operative setup for a left ankle (arrow).

Posterior Ankle Portal Establishment

Important structures are marked out, including medial/lateral malleolus, Achilles tendon, calcaneal tuberosity, and approximated course of the sural. Posteromedial and posterolateral arthroscopic portals are marked on either side of the Achilles tendon at the level of the tip of the medial malleolus. A small incision

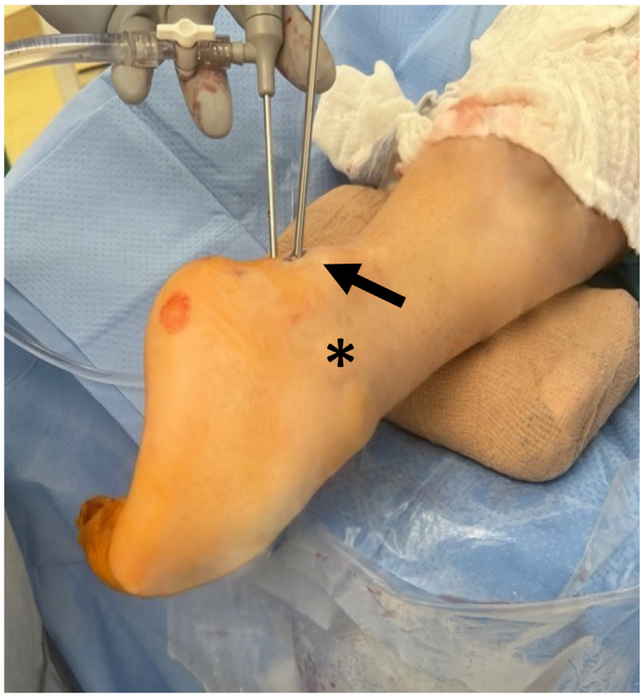

Fig 3. Clinical imagines demonstrating posterolateral and posteromedial arthroscopic portals. The Achilles tendon (arrow), medial malleolus, and lateral malleolus (*) are used as landmarks. The portals should be created at the level of the tip of the medial malleolus on either side of the Achilles.

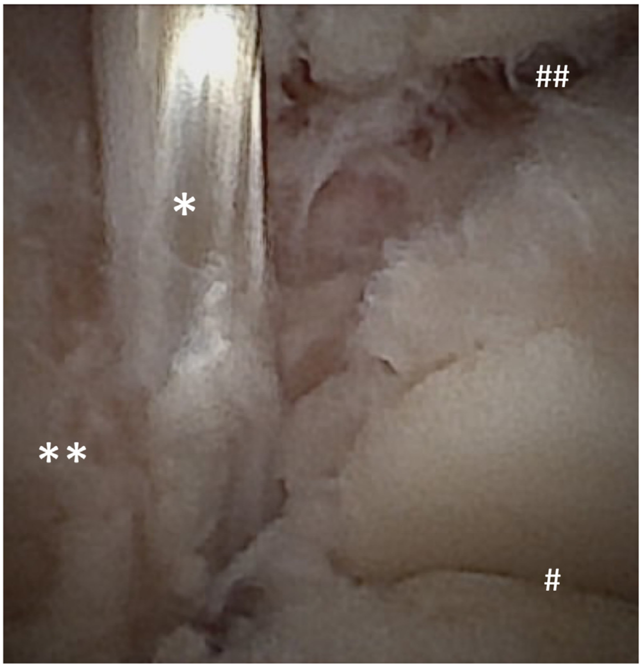

Fig 4. Arthroscopic view of posterior ankle: FHL tendon (*), medial ankle (**), subtalar joint (#), and tibiotalar joint (##). Visualization of FHL and circumferential isolation is critical. This can be confirmed by flexing and extending the great toe with visualization of tendon motion. (FHL, flexor hallucis longus.)

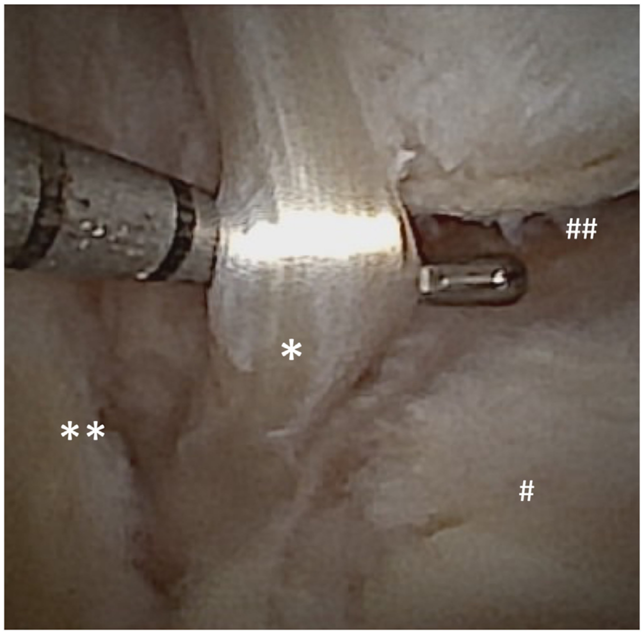

Fig 6. Arthroscopic view of the posterior ankle: FDL tendon (*), medial ankle (**), subtalar joint (#), and tibiotalar joint (##). Circumferential isolation of FDL before tenotomizing is critical. This can be confirmed by flexing and extending the lesser toes and visualizing motion of the tendon. (FDL, flexor digitorum longus.)

through skin, using the nick-and-spread technique, establishes the initial portal. We prefer making the posterolateral portal first (Fig 3).

Fig 5. Arthroscopic view of posterior: FHL tendon (*), medial ankle (**), subtalar joint (#), and tibiotalar joint (##). Once FHL is entirely free, an arthroscopic shaver or scissor can be used to tenotomize FHL, keeping sharp ends of the instruments pointed away from the neurovascular bundle. (FHL, flexor hallucis longus.)

Achilles Tenotomy (Hoke Achilles Lengthening)

At this point, an aggressive Hoke Achilles lengthening is performed using a #15 blade through the arthroscopic portals.[6] The goal is to cause near-complete release of the Achilles tendon, but if there is severe contracture, a complete transection can be performed. Manual stretch is applied after to gain dorsiflexion.

Posterior Ankle Arthroscopy

A 1.9-mm mini-arthroscope (NanoScope; Arthrex, Naples, FL) with blunt trocar is inserted. Low flow is used to reduce risk of fluid extravasation and possible compartment pressurization. With the arthroscope, identify the posterior recess, flexor hallucis longus (FHL) tendon, and posterior subtalar facet joint line. The orientation of these structures may be slightly altered from normal due to the severely contracted position (Fig 4).

FHL Tenotomy

On initial examination of the FHL tendon ensures clear circumferential visualization. The subtalar joint is identified and the FHL tendon is confirmed with movement of the great toe. Debridement can be achieved by using a 3.5-mm shaver. It is critical to ensure that the teeth of the shaver are pointed posterior (away from the FHL tendon) and that the FHL tendon is used as a safe zone border. The neurovascular bundle sits anterior/medial to the FHL, which needs to remain protected. Once there is a clear view, FHL tenotomy is performed at the level of

Fig 7. Arthroscopic view of the posterior ankle: PTT tendon (*), medial ankle (**), subtalar joint (#) and tibiotalar joint (##). Complete isolation is required before tenotomy. This can be confirmed by inverting and everting the ankle and visualizing motion of the tendon. (PTT, posterior tibial tendon.)

the subtalar joint with an arthroscopic scissor or with the shaver. Complete FHL release can be confirmed with movement of the great toe (Fig 5).

Flexor Digitorum Longus (FDL) Tenotomy

Dissection at this point is advanced anteromedially while maintaining visualization of the joint line. The FDL tendon is identified and the sheath is debrided for circumferential visualization. Once the FDL is isolated, a tenotomy can be performed with arthroscopic scissors or shaver. After complete release, the toes and midfoot are manually manipulated. The knot of Henry will have some variability and percutaneous toe tenotomies may be required to achieve desired correction (Fig 6).

Posterior Tibialis Tendon Tenotomy

The posterior tibialis tendon is identified and isolated in a similar fashion. The ankle is inverted and everted to confirm, then a tenotomy can be performed. After complete release, the toes and foot can be manually manipulated with steady pressure to allow for soft-tissue creep (Fig 7).

Tibio-Talo-Calcaneal (TTC) Arthrodesis

The tibiotalar and subtalar joint cartilage is denuded using arthroscopic visualization, small curettes, pituitary rongeur, and arthroscopic shaver. Once cartilage is removed from all surfaces, a small osteotome is used to fish-scale the joint surfaces. At this point fluoroscopic imaging is used to maintain alignment of the ankle in neutral dorsiflexion, 5° to 10° of external rotation, 5° of hindfoot valgus, and 5 mm of posterior talar translation.[7] Once an acceptable alignment is achieved, a guidewire is inserted through the calcaneus, talus, and into the distal tibia. A nick-and-spread technique is used to create an opening in the skin, subcutaneous tissue and soft tissue to the plantar calcaneus. An entry reamer is used to create a pathway into the distal tibia and the guide wire is removed. A ball tip guidewire is inserted into the same tract, which is confirmed on imaging. Sequential reaming is initiated over the ball tip guidewire, to a size 1.5 mm over the desired nail diameter. The nail is then inserted under fluoroscopic guidance, using a mallet when needed. Interlocking

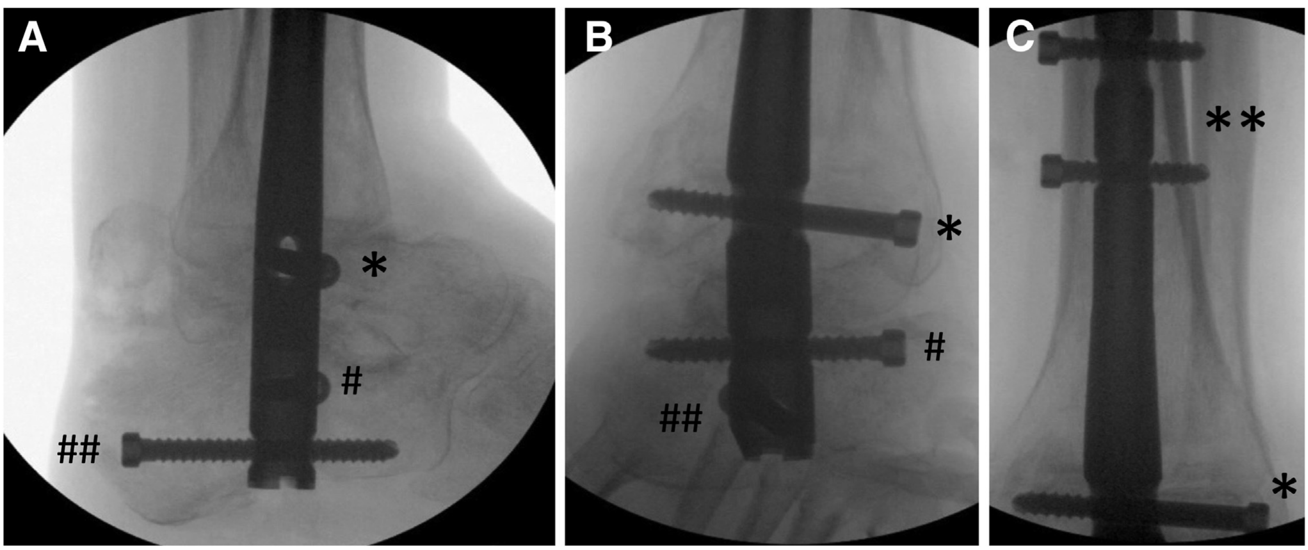

Fig 8. Intraoperative fluoroscopic radiographs including lateral (A) and anteroposterior (B, C) views following arthroscopically performed contracture releases and tibio-talar-calcaneal (TTC) triple fusion. The ankle is placed in neutral dorsiflexion, 5 to 10° of external rotation, 5° of hindfoot valgus, and 5 mm of posterior talar translation. * indicates lateral talar interlocking screw; ** indicates medial to lateral tibial screws; # indicates lateral to medial calcaneal interlocking screw; and ## indicates posterior to anterior calcaneal interlocking screw.

Fig 9. Immediate postoperative immobilization includes a well-padded splint in a posterior slab and "U" design (A, view from anterior to posterior of the foot; B, view down upon the dorsal foot; C, view from medial to lateral ankle). It is important to ensure the splint is well padded to prevent soft-tissue breakdown and pressure wounds.

screws are inserted as follows using the aiming arm: lateral talar interlocking, 2 interlocking screws medial to lateral in the tibia, lateral to medial then posterior to anterior calcaneal interlocking screws. Compression can be applied internally with some TTC nail constructs verse gentle malleting after each screw is placed. Fluoroscopic imaging is used to confirm acceptable alignment and fixation. In our technique, the Stryker TTC nail was used, however any nail can be used in a similar fashion. If bone graft is desired, the reamings can be saved and arthroscopically reinserted[8] (Fig 8).

Closure and Dressings

The wounds were irrigated with sterile saline. Incisions were closed with 3-0 Nylon in a simple portal stitch (Ethicon, Raritan, NJ). Xeroform and soft dressings and a well-padded posterior slab and "U" splint were applied (Covidien; Minneapolis, MN).

Postoperative Protocol

The goal is to allow for wound healing, prevent recurrence of deformity, and allow for fusion mass to consolidate.

Weight-Bearing

Patients maintain their splint for 10 to 14 days and undergo non−weight-bearing restrictions on the affected leg, while encouraged to perform straight leg raises, knee extensions and to wiggle their toes to prevent stiffness (Fig 9). At their 2-week appointment, patients are transitioned from a splint to cast or walking boot (which is treated as a cast). Their sutures

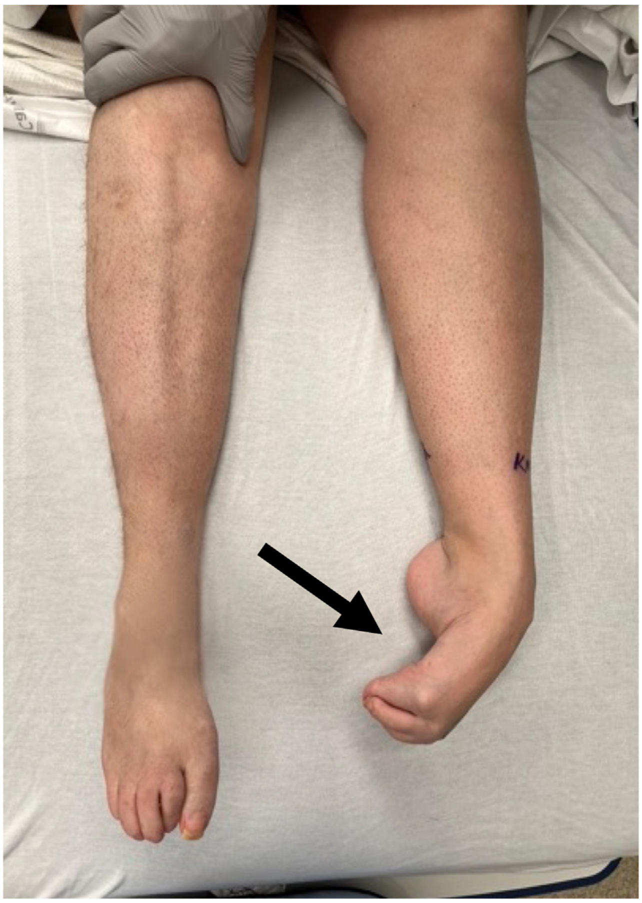

Fig 10. Clinical images of the patient from Figure 1 who underwent arthroscopically performed contracture releases and tibio-talar-calcaneal (TTC) triple fusion on their right ankle (arrow).

Fig 11. Clinical photo of a patient 6 and 9 months after bilateral arthroscopically assisted contracture releases with TTC fusion participating in a physical therapy session. Before this, they had not been able to stand upright for 2 years following their brain injury. (TTC, tibio-talar-calcaneal.)

are removed and incisions evaluated. They remain non—weight-bearing until 6 weeks after surgery, where they begin gradual, protected weight-bearing with crutches. Weight-bearing for transfers can be initiated earlier per patient-specific needs and circumstances. Physical therapy is initiated for gait training and safety. A night splint is used once the patient is out of their fracture boot for 3 months to prevent deformity recurrence.

Medication Regimen

A multimodal pain regimen including anti-inflammatories, neuropathic medications, and narcotics are recommended. We also recommend a stool softener, anti-nausea medication, and deep venous thrombosis prophylaxis in the postoperative period. Our patients are discharged on aspirin 81 mg to take twice daily for 14 days unless they are on other anticoagulation at baseline or are unable to take aspirin.

Recovery Time

We anticipate that the patients will return to baseline activities approximately 3 to 6 months' postoperatively. This varies depending on their presurgical functionality and goals (Fig 10).

Table 1. Pearls and Pitfalls

Pearls
- Arthroscopic approach limits soft-tissue violation, mitigating effects of skin contractures and resultant wound healing complications.
- Posterior arthroscopic portals provide complete access to release soft-tissue contractures and prepare subtalar/tibiotalar joints for fusion.
- Prone positioning allows access to contractures while improving ease of entry for the TTC nail.
- TTC nail allows early protected weight-bearing and reduces need for long-term bracing.
- In our technique, the Stryker TTC nail was used; however, any nail can be implemented.

Pitfalls
- This technique requires expert knowledge of the posterior ankle arthroscopic anatomy and can be difficult or unsafe for an inexperienced arthroscopist.
- Residual contractures may persist and need individual percutaneous toe tenotomies distal to the knot of Henry.
- Single-stage reconstruction still applies immediate tension across contracted skin, which can tear or require tapered releases.

Risks and limitations
- Only an experienced arthroscopist familiar with posterior ankle arthroscopic anatomy should consider this approach.
- Additional toe contractures may remain and need percutaneous tenotomies distal to the knot of Henry
- Debridement medial could potentially lead to injury of the posterior tibial neurovascular bundle.
- Skin contractures may tear or need tapered releases.

TTC, tibio-talar-calcaneal

Discussion

ABIs can cause devastating life-long impairments requiring significant medical and surgical interventions. The development of rigid contractures of the lower extremity (SEF) can prevent ambulation, standing, and transferring for affected patients. The treatment of these contractures requires a multimodal approach of anti-spasmodics, injections, physical/occupational therapy, in combination with customized bracing. Even with optimal treatment and medical observation, contractures may become rigid, creating a bed-bound environment. We feel a single-stage minimally invasive hindfoot fusion approach can be safe and effective to restore function (Fig 11) (Table 1).

Neurologic lower-extremity contractures are a challenging phenomenon that affect a significant number of the population each year. These patients can experience severe mobility restrictions, long-term pain, deformity, wounds, and multiple trials of nonoperative treatments. This multimodal treatment approach for their deformities can lead to significant health care costs. Our proposed method of treatment aims to decrease the burden of skin breakdown and wounds from long term bracing, reduce the risk of deformity recurrence and help patients regain lower-extremity function.

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