CHAPTER **24**

VARIED TECHNIQUES IN TARSAL COALITION RESECTION AND INTERPOSITION: A Comparative Analysis of 3 Case Reports

Peninnah Kumar, DPM
A. Louis Jimenez, DPM

INTRODUCTION

Tarsal coalition is a congenital anomaly characterized by the atypical union (osseous or fibrous) between bones in the rearfoot that can result in restriction or absence of motion. This pedal variance has been noted since archeological specimens dating from 900 to 1000 AD confirmed their presence in the ruins of a Mayan temple in Guatemala, and a pre-Columbian Indian skeleton in Ohio. In 2005, Silva presented 2 cases of nonosseous calcaneonavicular coalition in older specimens recovered from Portuguese burial sites dating from between the late Neolithic and early Bronze Age, circa 3600 to 2000 BC. The first recognized visual details of the condition were documented by Cruveilhier in 1829 and Zuckerland in 1877, who both portrayed anatomic descriptions of a tarsal coalition.

The most reasonable etiology of tarsal coalition is a failure of primitive mesenchyme to segment by cleavage in the 72-mm fetus. The specific type of coalition more than likely represents a genetic mutation that is responsible for the mesenchymal segmentation anomaly. The inheritance pattern appears to be autosomal dominant and the amount of penetrance varies with reports. Most studies have determined the incidence of tarsal coalition is approximately 1%; however this statistic may be flawed due to the fact that many coalitions go undiagnosed in the asymptomatic and nonosseous subtypes. The two most common types of tarsal coalition are the calcaneonavicular (43%) and the talocalcaneal (48.1%) types. The occurrence of bilateral tarsal coalition varies in the literature but is generally believed to be 50% or more.

Tarsal coalitions may present with several coexisting conditions including but not limited to pes planovalgus, ankle equinus, posterior tibialis tendon dysfunction, peroneal spasm, and/or other segmental pedal misalignment with or without degenerative arthrosis. The heel raise test, which is the inability of the rearfoot to supinate while performing a single heel raise, may suggest the presence of coalition to the practitioner. On physical examination, a talocalcaneal coalition and calcaneonavicular bar may manifest with pain in the medial rearfoot at the sustentaculum tali, just inferior to the medial malleolus, as well as tenderness to palpation just distal to the lateral malleolus and sinus tarsi. Imaging is a key component and may be the first line in diagnosis of tarsal coalitions.

Calcaneonavicular coalitions are best identified on the MO view, while talonavicular coalitions are visible on the lateral and anterior-posterior views. Although talocalcaneal coalitions may be identified on the lateral view, they are well visualized with a "modified calcaneal axial view" at 45 degrees, also known as a Harris-Beath series. Radiographic features that have been noted throughout literature include but are not limited to the presence of rearfoot arthrosis, dorsal talar beaking, blunted lateral talar process, "ant-eater nose" sign, reverse ant-eater sign, C sign, drunken waiter sign, a ball-and-socket ankle joint, an absent middle facet sign, and a dysmorphic talus, and/or sustentaculum tali. Advanced imaging such as computed tomography (CT), magnetic resonance imaging (MRI) and more recently 3D reconstruction, have proved beneficial in distinguishing between osseous or fibrous unions, quantitative presence of arthrosis and detailed surgical planning.

In terms of classifications the Downey classification has been frequently used to help aid in surgical planning. The classification consists of several parameters that include the patient's age, the articular involvement, and the degree of secondary arthritic changes in surrounding joints. The classification suggests different procedures according to these parameters and these can be further reviewed in the 1991 article by Downey et al: Tarsal Coalitions: A Surgical Classification Downey article in the *Journal of American Podiatric Medical Association*.

LITERATURE REVIEW

The first written description of a tarsal coalition is attributed to a French naturalist, Buffon in 1769, however the first radiologic depiction of a tarsal coalition took place in 1898 by Kirmisson, only 3 years after Roentgen discovered x-rays. Since then several studies and reviews on etiology, diagnosis

and surgical techniques of tarsal coalitions have been documented. In terms of incidence of the condition Pfitzner's cadaveric study from 1896 is noted as the most credible in terms of the most accurate number. Pfitzner's cadaveric dissection consisted of 520 feet of skeletons evaluated for talocalcaneal coalition and calcaneonavicular coalition, and he identified an incidence of almost 6%. In 1927 Badgley was the first to describe a technique for resection of a coalition, which detailed an anterolateral approach over a calcaneonavicular coalition, resection of at least 1 cm of the coalition, resecting a block rather than a wedge, and interposition with the head of the extensor digitorum brevis (EDB) muscle. Despite early studies recommending triple arthrodesis, resection still seems to be the more-utilized treatment of calcaneonavicular coalitions, especially in younger patients, and has been backed up with several long-term studies revealing 77-100% good or excellent results.

Triple arthrodesis used to be the primary procedure of choice for middle facet coalitions prior to advancements in imaging and preoperative surgical imaging. Currently the general theme in literature is that arthrodesis is reserved for recurrence after resection and for feet with established degenerative changes since resection, and interpositional arthroplasty have yielded good-to-excellent results. Comfort and Johnson reported a 77% success rate with resection when the coalition involved about one-third of the total surface area of the subtalar joint on CT. Several studies have also evaluated the benefit of interposition after resection as seen by Moyes and colleagues who performed a retrospective review of 17 calcaneonavicular coalition resections, of which 10 had EDB interposition and 7 had no soft-tissue interposition. Three in the second group had recurrence of the coalition along with their symptoms. Evidence for the ideal interposition graft remains controversial, which is why the authors of this article have embraced the need for future studies to evaluate what products may be beneficial as interposition options.

SURGICAL PEARLS

The following tips are suggestions to increase the surgeon's chances of a positive outcome in any tarsal coalition case:

- Attempt to resect coalitions prior to arthritic changes.
- Resect coalitions as early as possible and especially if noted during the adolescent period.
- Subtalar joint arthrodesis is advocated in cases of associated degenerative arthritis of the subtalar joint seen in talocalcaneal coalitions in an effort to avoid midtarsal joint articular changes.
- Perform this procedure under tourniquet control as medullary bleeding can be a hindrance to intraoperative visualization and technical details.
- Place some form of interpositional spacer to help prevent reoccurrence at the resection sites.
- Start early range of motion as soon it is reasonably acceptable pending no complications with the patient's postoperative course.
- Performing additional reconstructive procedures to address coexisting conditions associated with the coalitions will be beneficial to the patient's long term functionality.

CASE REPORTS

The following case reports were all performed with varied interposition techniques after resection to ascertain what other materials can be successful as an interposition option. A detailed description of the authors' preferred technique will be described in Case 3.

Case 1

A 27-year-old man presented to the clinic and related pain since 2004 in his left ankle. He stated that he was in an airborne division where he would parachute and jump from high heights. He indicated one bad jump where his left foot had become significantly swollen and discolored but the medical team found no fractures. The veteran indicated that he has tried anti-inflammatories, injections, bracing, shoes, and multiple other conservative modalities without success. The symptoms were getting progressively worse and he rated the pain as a 7-8 out of 10. Surgical intervention was undertaken.

Upon physical examination there was significant tenderness with palpation at the medial aspect of the subtalar joint and at the calcaneonavicular joint. There was diminished passive range of motion at the left ankle joint and subtalar joint. CT and radiographic imaging verified a possible fibrocartilaginous calcaneonavicular bar and an osseous talocalcaneal coalition with associated degenerative changes including a large talar exostosis. After the patient's neurovascular status was deemed viable it was decided that the most feasible surgical option would include a subtalar joint fusion, calcaneonavicular bar resection with interposition, and talar exostectomy.

A subtalar joint fusion was performed with one 6.5 cannulated screw followed by a talar exostectomy and calcaneonavicular bar resection. In this case a Synovis

Vascuguard implant was utilized as the interposition option. The Vascuguard patch is derived from bovine pericardium and Synovis claims this graft resists calcification and mineralization when placed on bony articular surfaces. An Ascencion Renovo bone suture was then utilized to reattach the EDB in its proper position.

Postoperatively the patient recovered with no significant complications and at his 1-year follow-up presented with a fully consolidated subtalar joint fusion and no reoccurrence at his calcaneonavicular bar resection site. The veteran continues his daily activities with no postoperative pain and a fully functional limb.

Case 2

A 50-year old woman presented to the clinic with pain in both her feet that had been present for approximately 10 years. The veteran states she had been wearing generic inserts, which helped a little, but the pain is now causing her to decrease her daily activities. The patient related she had received an injection in the past, which gave minimal relief and reported that the pain was most tender to the tops of her feet and pointed to the area of the sinus tarsi. She related that the pain exacerbated her lower back problem and she would like to proceed with surgical intervention.

Physical examination revealed pain noted with inversion/eversion of the subtalar joint, but no crepitus. Localized tenderness was also noted to sinus tarsi region, with the right foot being worse than the left. CT imaging revealed findings consistent with bilateral fibrocartilaginous calcaneonavicular bar with additional associated hypertrophic changes at the midfoot as well as talar beaking, with the right being greater than the left. The surgical plan involved calcaneonavicular bar resection with interposition as well as a talar head exostectomy and ganglion cyst removal of the right foot.

In this case, after resection of the calcaneonavicular bar, a Stryker TissueMend graft was placed in the site to prevent reossification. TissueMend is derived from fetal bovine dermis rather than pericardium in the first case. The graft was sutured down to the periosteum and surrounding deep fascia utilizing 3-0 vicryl. The patient went on to an uneventful recovery and at her 1-year follow-up related no pain associated with the surgery. Imaging revealed a clear resection site with no reossification.

Case 3

A 29-year-old man presented to clinic with a chief complaint of pain of about 2 years duration in the lateral part of his right foot that he described as "aching/sore" in nature and rated as a 7-8 out of 10. The veteran related that weight-bearing on the foot made the pain worse, and related that icing his foot reduced the pain. The patient related a history of ankle sprains of his right ankle in 2009 while in the Marine Corps and that he was ready for surgical intervention.

Upon physical examination it was noted that patient had pain with inversion of the subtalar joint as well as pain with palpation about the most lateral aspect of the navicular. Imaging revealed not only an osseous calcaneonavicular coalition but also a middle facet coalition (Figure 1). Surgical intervention for the patient included a calcaneonavicular coalition resection with interposition and a middle facet coalition resection.

In terms of the calcaneonavicular bar resection, a curvilinear incision was made, starting inferior to the lateral malleolus extending distal medially to the navicular bone (Figure 2). The incision was deepened through subcutaneous tissues where the muscle belly of the EDB was identified at the inferior margin where the EDB meets with the peroneal retinaculum. The most inferior edge of the EDB was incised keeping the EDB muscle retinaculum intact (Figure 3). Proximally, the EDB was released from its attachment to the calcaneus and talus. A "0" suture was placed in the EDB muscle belly and the belly was cleanly dissected off the bar between the calcaneus and navicular (Figure 4). The EDB muscle belly was retracted distal medially. An osteotome and was used to mark the entry points into the osseous bar (Figure 5). The angulation of the osteotome should be such that the bar resection is wider superiorly than inferiorly to allow the osseous bar to be

Figure 1A. MO radiograph reveals calcaneonavicular bar.

Figure 1B. Lateral view.

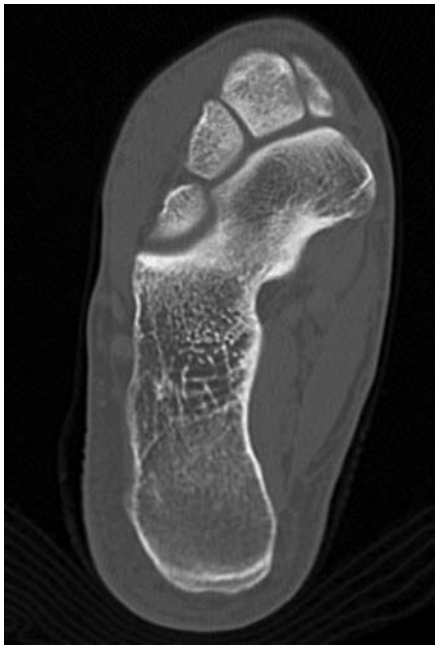

Figure 1C. Computed tomography reveals obvious synostosis between the navicular and calcaneus.

Figure 1D. Partial synostosis of the subtalar joint middle facet.

Figure 2. Oblique incision over calcaneonavicular bar to be resected.

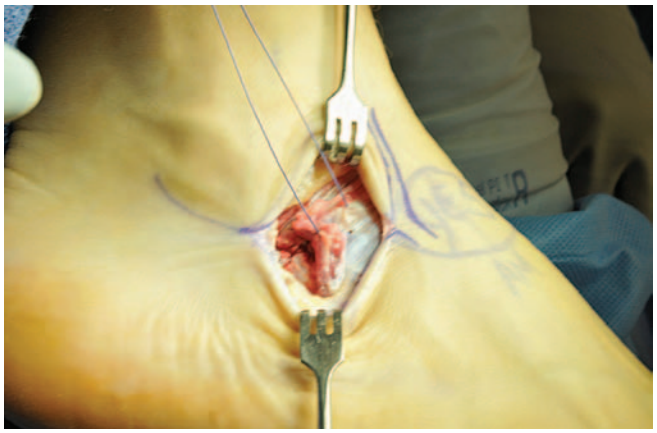

Figure 3. The inferior border of the extensor digitorum brevis muscle meets with the retinaculum over the peroneal tendon. The extensor digitorum brevis fascia is kept intact by making an incision superior to the inferior peroneal retinaculum.

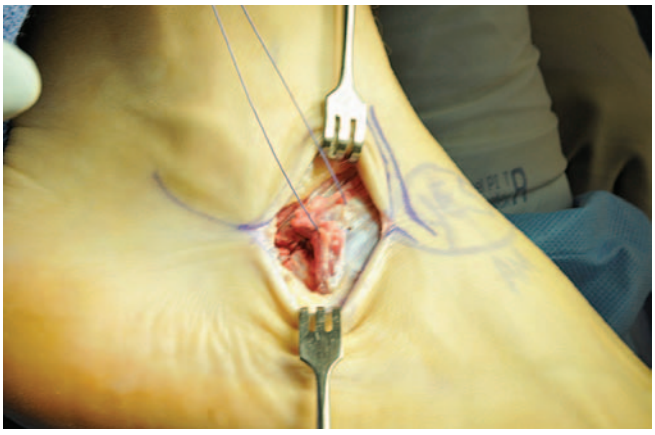

Figure 4. Suture placed within muscle belly of the extensor digitorum brevis to aid in retraction.

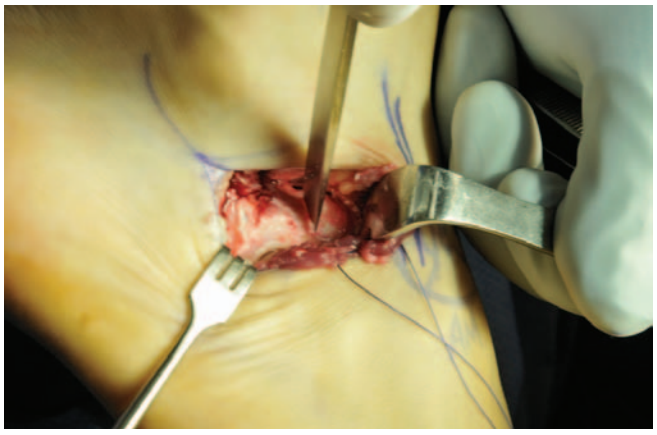

Figure 5. Extensor digitorum brevis muscle belly retracted anteriomedial. An osteotome marks the initial cut superior to the calcaneus and calcaneonavicular joint.

resected and removed easily. Reversing the cuts and creating a wider bar at the base will make it more difficult to remove, necessitating more cuts into the bone in order to remove the bar. Adequate resection is usually 2-3 cm (Figure 6). At this point, the subtalar joint and midtarsal joint moved freely. The bare osseous segments were then covered with bone wax to prevent osseous regrowth between the bones. The EDB was then sutured in place (Figure 7) and the wound was closed in layers (Figure 8).

Regarding resection of the middle facet coalition, the exact location of the bar was established by placing a Kirschner wire from the lateral side of the sinus tarsi, directing it medially until the skin over the middle facet was tented. At this location a 5-6 cm skin incision was marked where the skin tented (Figure 9). Following subcutaneous dissection, the deep fascia was incised and the tibialis posterior and flexor digitorum longus tendons were identified. The tibialis posterior was reflected superiorly (Figures 10A and 10B) and the flexor digitorum longus retracted inferiorly (Figures 10C and 10D). The periosteum was then incised over the suspected synostosis site and a small triangular wedge of bone with the base medial was resected (Figure 11). Appropriate osseous resection was accomplished, enough to see the remaining articular surfaces of the middle facet (Figure 12). Range of motion was then performed and revealed excellent subtalar joint excursion. Bone wax was then placed over the cancellous surfaces as an interface to diminish osseous union (Figure 13). The patient was allowed to be partial weightbearing immediately post-operatively and range of motion exercises were started 7-10 days postoperatively.

The patient returned for his 2 week postoperative visit with no pain. Radiographs revealed satisfactory resection sites at this visit (Figure 14). Consequently the patient was lost to follow-up after this visit. When contacted it was revealed that he was feeling so good he did not feel the need to return for follow-up.

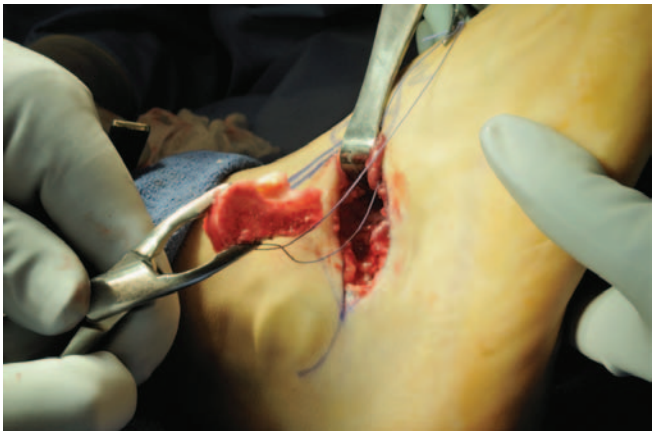

Figure 6. Rongeur holding 3 cm section of calcaneonavicular bar resected.

Figure 7. Extensor digitorum brevis muscle belly sutured back in position.

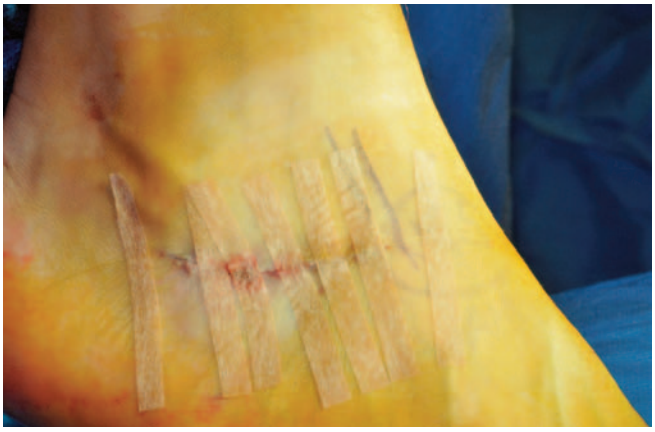

Figure 8. Completed skin closure.

Figure 9. Planned incision marked over middle facet.

Figure 10A. After deep fascia is cut, the tibialis posterior tendon is identified, and retracted superiorly.

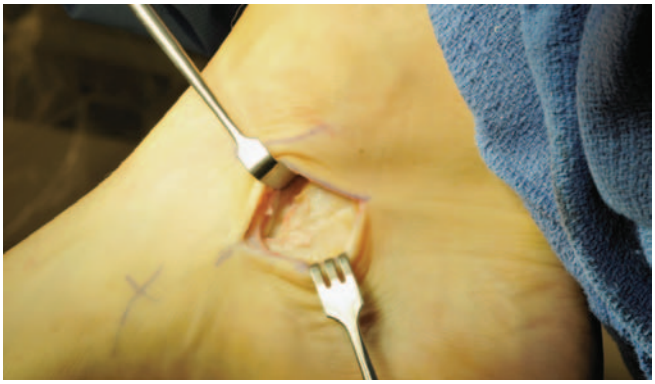

Figure 10B. Tendon is retracted superiorly.

Figure 10C. The white flexor digitorum longus tendon is identified at the 2 o'clock position.

Figure 10D. The tendon is retracted inferiorly.

Figure 11A. Osteotome removing small triangular wedge of bone from suspected middle facet bar area.

Figure 11B. Suspected middle facet bar area.

Figure 12. Middle facet cartilage evident after bone removal.

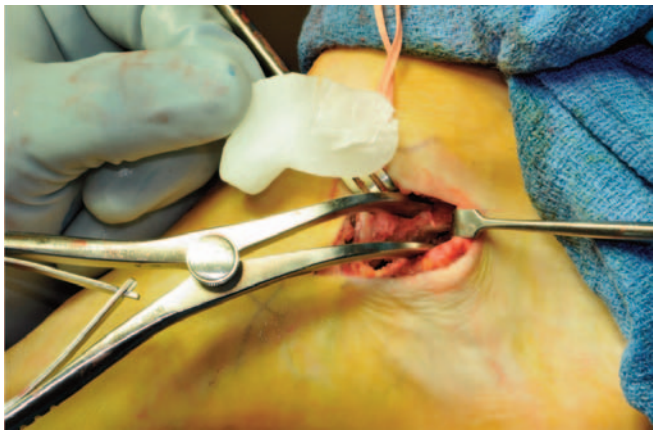

Figure 13A. Bone wax is placed on raw bone surfaces.

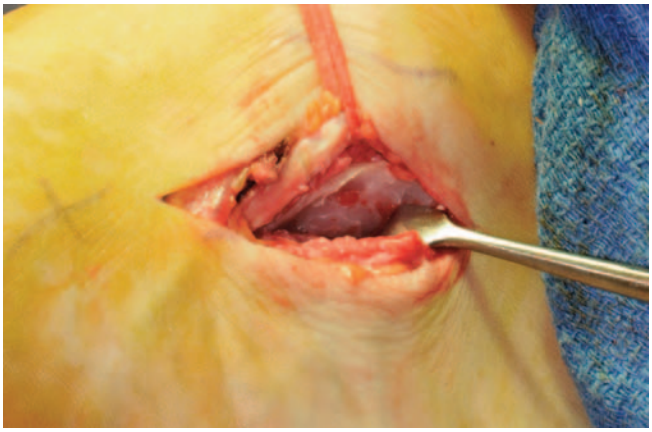

Figure 13B. Bone wax is placed into raw bone surfaces while middle facet is distracted.

Figure 14. Postoperative oblique and lateral radiographic views identify absence of bone from resected surfaces.

RESULTS

Although this article highlighted a small patient caseload it was fairly evident that interposition was key in assisting these patients obtain a fully functional pain-free limb. All 3 cases had excellent results with the first 2 having a thorough and detailed 1-year follow-up. The last case we were not able to review imaging for a 1-year follow-up but it was helpful to know this individual was functioning normally with no issues after his surgical intervention. The 1-year case follow-ups helped the authors establish that the resection sites remained free of reossification or regrowth, and that the interposition techniques were successful for at least this time period.

SUMMARY

Tarsal coalitions have been recognized and documented throughout time with different techniques and interposition choices. It is the authors' opinion that in order to prevent reoccurrence of a coalition, some type of interface should be used at the resection sites. Even though primarily the EDB muscle has been the most common interface choice, the authors have had success with bone wax and synthesized grafts. The key pearl that should be noted is that it is vital to complete a detailed examination and workup to determine the best procedures and techniques for each patient's long-term positive outcome. Further long-term clinical studies with a higher case volume comparing interposition materials may be beneficial in determining their usage in tarsal coalitions.