Tarsal Coalition and Painful Flatfoot

Kent A. Vincent, MD

Abstract

The prevalence of tarsal coalition is probably 1% or less. The two sites most commonly affected are the calcaneonavicular joint and the middle facet of the talocalcaneal joint. Diagnosis should be suspected in the preteen or teenage patient with insidious or sudden onset of pain in the midfoot to hindfoot associated with a lack of motion in the subtalar joint. Initial treatment with immobilization or an orthosis may relieve symptoms, but most patients will have persistent symptoms that warrant surgical correction. Long-term results indicate that excision of the coalition is moderately successful in relieving symptoms in the calcaneonavicular bar. Long-term success with excision of subtalar bars is less clear, although early relief of symptoms is usually possible.

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Tarsal coalition is a congenital anomaly, with variable levels of union between two of the tarsal bones. This results in rigidity of motion in the foot in the planovalgus position. The clinical syndrome has been referred to as the "peroneal spastic flatfoot." True spasticity of the peroneal musculature is not a causative factor, nor is it probably even a result of the coalition. Rather, lateral joint pain from restricted joint articulation is seen on examination with attempts to move the subtalar joint through its range of normal motion, especially inversion.

History

The first description of tarsal coalition was probably in the French literature by Buffon in 1750. The calcaneonavicular bar was described radiographically in 1921 by Slomann, who used a 45-degree oblique film. In 1927, Badgley recognized the relationship of the calcaneonavicular coalition to the syndrome of peroneal spastic flatfoot. The first description of use of the axial radiographic view to show middle-facet talocalcaneal coalition was by Korvin in 1934. Harris and Beath[1] later popularized this view and also described the clinical entity of the talocalcaneal coalition with peroneal spastic flatfoot in 1948. The lateral oblique radiograph has subsequently been shown to be useful in identifying the anterior-facet talocalcaneal bar.[2] Tomography has also been found to be useful for identification of anterior-, middle-, and posterior-facet coalition.[3] Computed tomography has now become the standard for identification of talocalcaneal bars.[4]

While the calcaneonavicular and talocalcaneal joints are the most common sites of tarsal coalition, other sites have been reported, among them the talonavicular, calcaneocuboid, cubitonavicular, and naviculocuneiform joints. Occurrence at each of these sites is very rare and will generally be excluded from the following discussion.

Etiology

The cause of tarsal coalition is assumed to be a lack of differentiation of mesenchymal tissue, with subsequent failure of formation of the normal joint. Confirmation of this hypothesis is difficult, but is supported by the finding of intertarsal bridges in fetal tissue.[5]

Prevalence and Heredity

The prevalence of tarsal coalition in the US population is probably around 1%. However, the incidence of symptoms in patients with this abnormality is not known. Bilaterality has been reported in 60% of persons with calcaneonavicular coalitions and in 50% of those with talocalcaneal coalitions.[6]

The most complete review of the genetic incidence of tarsal coalition was reported by Leonard.[7] His findings suggest that tarsal coalition is inherited in an autosomal

Dr. Vincent is Staff Orthopedist, Shriners Hospital for Children, Portland, Oregon; and Assistant Professor, Department of Orthopedics, Oregon Health Sciences University, Portland.

Reprint requests: Dr. Vincent, Shriners Hospital, 3101 SW Sam Jackson Park Road, Portland, OR 97201-3905.

dominant pattern with a high level of penetrance. Somewhat surprisingly, the affected first-degree relatives in that study did not always have a coalition involving the same joint. This suggests genetic nonspecificity of the joint involved even if the autosomal dominant pattern holds.

Classification and Associated Conditions

Classification of the entity is most commonly done on the basis of the anatomic location.[6] The talocalcaneal coalition is separated into the anterior, middle, and posterior facets. The middle facet is by far the most common site. Coalitions may also be classified on the basis of completeness of ossification. The completely ossified bar is a synostosis; the partially cartilaginous bar is a synchondrosis; and the coalition spanned by fibrous tissue is a syndesmosis.

Tarsal synostoses occur frequently in association with the spectrum of fibular hemimelia (Fig. 1) and proximal focal femoral deficiency. Patients with a "ball-and-socket" ankle joint and missing lateral rays, whether also associated with fibular hemimelia or not, frequently present with dense synostoses of the subtalar and talonavicular joints that show no evidence of a joint. Conditions involving phocomelia or hypoplastic femur have a high incidence of coalitions as well. Other reported associations include symphalangism, carpal coalitions, and both Apert and Nievergelt-Pearlman syndromes.

Pathologic Motion

Tarsal coalition has a restrictive effect on subtalar motion. With middle-facet talocalcaneal coalitions, this motion restriction is particularly notable on physical examination. In the patient with a calcaneonavicular coalition, restriction of subtalar-joint motion is less obvious because of the greater range of motion and higher degree of ligamentous laxity common at the typically younger age at presentation. One must infer, however, that the loss of normal movement between the calcaneus and the navicular restricts the normal rotary and gliding motion of the subtalar joint as well.

The axis of motion of the subtalar joint in normal gait is described in reference to a line passing from the middle of the calcaneus to a point between the first and second metatarsal heads. Its motion occurs through an axis line that is pointed approximately 45 degrees downward from the horizontal (from posterior to anterior) and is internally rotated 15 degrees from the reference line. Thus, in normal walking, the subtalar joint orients the foot from relative external rotation and valgus in early stance phase to internal rotation and varus in late stance and most of swing phase. The internal rotation of the subtalar joint complements tibial external rotation, which is occurring at the same time in the gait cycle. When subtalar joint motion is restricted, the talonavicular, calcaneocuboid, and more

Fig. 1 Radiographs of a 14-year-old girl with fibular hemimelia. **A,** Ball-and-socket ankle joint. **B,** Lateral view shows loss of the normal arch. **C,** Oblique radiograph demonstrates the four-toed foot and complete talocalcaneal coalition.

distal joints must make up for the lost rotation, which results in flattening of the foot and a valgus appearance of the foot in the horizontal plane. The restriction in motion may eventually result in arthrosis of the posterior facet of the subtalar joint, which may contribute to symptoms.

Another type of subtalar-joint motion restriction in tarsal coalition is the gliding type.[8] In normal gait through stance phase, the calcaneus slides forward on the talus as foot dorsiflexion occurs. Toward the end of dorsiflexion, the navicular and the cuboid slide slightly dorsally on the talus and calcaneus, respectively. When subtalar motion is restricted, the forward glide of the calcaneus under the talus is removed, and the dorsal glide of the transverse tarsal joint becomes a hingelike motion. As the navicular dorsiflexes in a hinge fashion on the talus, a small amount of periosteal stripping may occur at the level of the capsule, which creates the characteristic talar beaking seen on lateral radiographs.

Presentation

During infancy and the early walking years, the patient with a tarsal coalition seldom has pain, and as a result the condition is rarely recognized. Presentation of symptoms seems to correlate with the age at ossification of the coalition. Generally, the patient with a calcaneonavicular coalition presents with pain and dysfunction in the age range of 9 to 13 years.

The patient with a subtalar joint coalition tends to present slightly later, in middle or late adolescence. Heavier and more active patients tend to present earlier. The chief complaint from parents is frequently that the child is flat-footed. The child usually complains of pain with activity. Frequently an injury or "sprain" precipitates the onset of symptoms.

Physical examination should center on subtalar joint motion. It is also helpful to note the rotational characteristics of the femora and tibiae. External femoral and tibial torsion frequently results in the perception of flat-footedness that is not pathologic. The patient should be examined from the front, the rear, and the side while walking. The hindfoot will usually be in a valgus position, not swinging into normal varus when the patient is asked to rise up on the toes.

It is generally best to then examine the patient in a sitting position with passive simulation of subtalar motion. To do this, the calcaneus is grasped in one hand, and the midfoot and head of the talus are held in the other. With the hand holding the midfoot kept steady, an attempt is made to rock the calcaneus into varus and plantar flexion. This maneuver helps to remove the coronal plane motion that occurs through the ankle joint. One needs to have some experience with normal joints before applying this maneuver to the abnormal joint.

With the attempted inversion maneuver, the patient typically complains of pain in the region of the sinus tarsi, sometimes with radiation to the dorsum of the foot. Patients rarely complain of radiating pain to the posterolateral calf area, which would be expected with peroneal muscle spasm. Rather, the pain is usually characterized more as a deep joint pain in the dorsolateral foot, which is triggered by this hindfoot inversion motion.

Radiologic Evaluation

Appropriate workup of the patient with the suspected diagnosis of tarsal coalition is initiated with a series of plain radiographs. These include anteroposterior, lateral, 45-degree oblique, and axial views of the foot.

For the more common calcaneonavicular bar, the 45-degree oblique radiograph is the examination of choice. The radiographic column is placed at a 45-degree angle off the tibia, with the foot in the neutral position and the cassette on the posteromedial side of the foot. The radiographic findings will vary from complete ossification of the coalition to the appearance of a pseudarthrosis (Fig. 2). In questionable cases, a slightly different obliquity of the x-ray plane may be required to best demonstrate the coalition. The calcaneus and navicular usually have the look of flowing toward each other in a wide band that is not seen on normal radiographs. A narrow pointed extension of the calcaneus toward the navicular may also be seen, without an appearance of pseudarthrosis, which may be indicative of a pathologic cartilaginous coalition. An occasionally associated finding is the hypoplastic talar head.

Secondary findings to note on the lateral radiograph include talar beaking (Fig. 3), narrowing of the posterior subtalar-joint facet space, and broadening of the lateral process of the talus. The presence of these radiographic findings tends to correlate with higher pain levels.

The talocalcaneal coalition may be seen on the axial view. In our experience, however, this is not visualized reliably.

As it is generally not possible to differentiate the anatomic site of a coalition on the basis of the history and physical examination, the four radiographic views already mentioned should be completed first. If a calcaneonavicular coalition is seen on the oblique view, usually no further diagnostic workup is required unless a very rare double coalition

Fig. 2 Various appearances of the calcaneonavicular coalition as depicted on 45-degree oblique radiographs of the foot. **A,** Pointed bone ends with cartilaginous space between. **B,** Nearly complete coalition. **C,** Wide bone base and appearance of a pseudarthrosis between the calcaneus and the navicular in a patient with bilateral coalitions. **D,** When a 45-degree view is taken with the radiograph cassette placed flat on the floor, a "stretched" view of the foot is created, which is sometimes helpful in defining the coalition area. **E,** A 45-degree oblique radiograph of an 11-year-old with calcaneonavicular coalition. **F,** Postoperative oblique radiograph of the same patient demonstrates wide bone resection (with extensor digitorum brevis interposition).

is suspected. If a talocalcaneal coalition is suspected after the physical and radiographic examinations are completed, the next step should be to obtain a computed tomographic (CT) scan of the foot (Fig. 4). The CT scan most reliably shows both middle-facet and anterior-facet joint abnormalities in the subtalar joint. Arthrography has been reported to be a reliable technique, but since the advent of CT scanning its clinical use has diminished in importance.

Treatment

Conservative Management

Some patients will present with incidental radiographic findings and no pain or only minimal pain. These patients do not require treatment, but follow-up is warranted, particularly if the condition is discovered during the growth years. When pain is a major complaint, a number of conservative measures can be tried. The use of a heel cup with medial-wedge or longitudinal arch supports may relieve minor symptoms. For more severe symptoms, the next conservative measure to try is a short-leg walking cast with slight varus mold for 2 to 4 weeks. Most patients will be relieved of pain while in the cast. This is then followed by the use of a University of California Biomechanical Laboratory (UCBL) orthosis.

Moderate long-range success has been reported after use of a conservative routine of manipulation with the patient under anes-

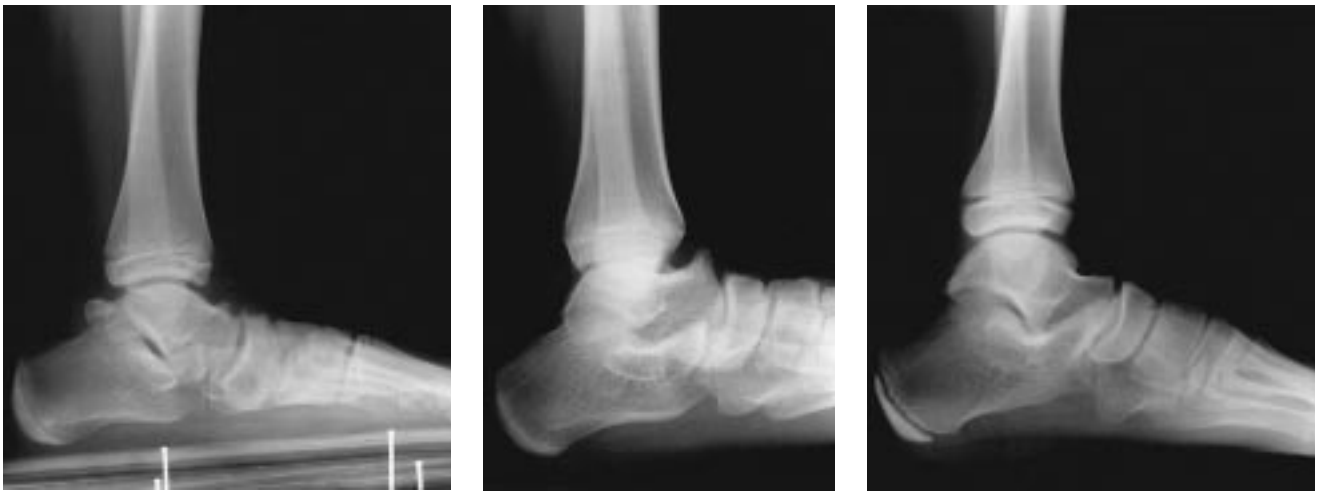

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Fig. 3 Lateral radiographs of patients with calcaneonavicular coalition. **A,** Dorsal talonavicular beaking and talar hypoplasia. **B,** Talar beaking and broadening of the lateral talar process. **C,** Mild talonavicular beaking.

thesia followed by either casting or use of an orthosis. Braddock[9] reported on a series of 28 patients (43 feet) who were treated with this routine and followed up for an average of 21 years. Half of these patients continued to have minor symptoms over the long term, but only 10% had disabling pain that was considered to warrant surgery. Recently, manipulation of the subtalar joint under anesthesia has fallen into disfavor because subsequent reports have not duplicated Braddock's results. Many patients have been intolerant of the foot position created in the cast or have experienced increased symptoms after cast removal.

Our preferred sequence of treatment for symptomatic calcaneonavicular and talocalcaneal coalitions is the same. The first step is to try immobilization in a weight-bearing short-leg cast for 2 to 4 weeks, followed by fitting for a UCBL orthosis. If the patient has pain relief with the cast, but the pain recurs with the orthosis, a second cast may be considered. If immobilization and use of the orthosis are not effective, surgery should be considered.

Surgical Treatment of Calcaneonavicular Coalition

Surgery becomes a consideration when pain is a persistent problem and conservative measures have failed. The first option usually considered is a wide resection of the osseous or cartilaginous bar, followed by interposition of the extensor digitorum brevis muscle into the newly created defect. Theoretically, mobilization of the calcaneus from the navicular should improve mobility and mechanics at the subtalar joint. This mobility may not be demonstrated intraoperatively. It is not known whether the joints of the hindfoot and midfoot are able to recreate normal mobility and sliding mechanics after resection of a coalition.

Certainly, the younger the patient, the more ideal for resection, because of the increased potential for return of joint mobility. There is no upper age limit for consideration of calcaneonavicular bar excision. Evidence of mild degenerative changes seen on radiographs may be accepted before surgical resection. These include mild talonavicular beaking and broadening of the lateral process of the talus. In some instances, resolution of mild talar beaking will be seen after resection of the coalition.

Reports of results from surgical resection and extensor digitorum brevis interposition have been generally very encouraging, with good pain relief in 80% or more of patients.[6,10] The interposition of the extensor digitorum brevis muscle is an integral part of the long-term success of the procedure, as a high rate of recurrence of bone reformation has been reported without this modification.[11]

Our preferred technique is to use an oblique incision made slightly distal to that needed for exposure of the subtalar joint. The coalition is resected to create a defect at least 1 cm in length. The origin of the extensor digitorum brevis is then mobilized, and two Keith needles are used to secure the muscle to either plantar fascia

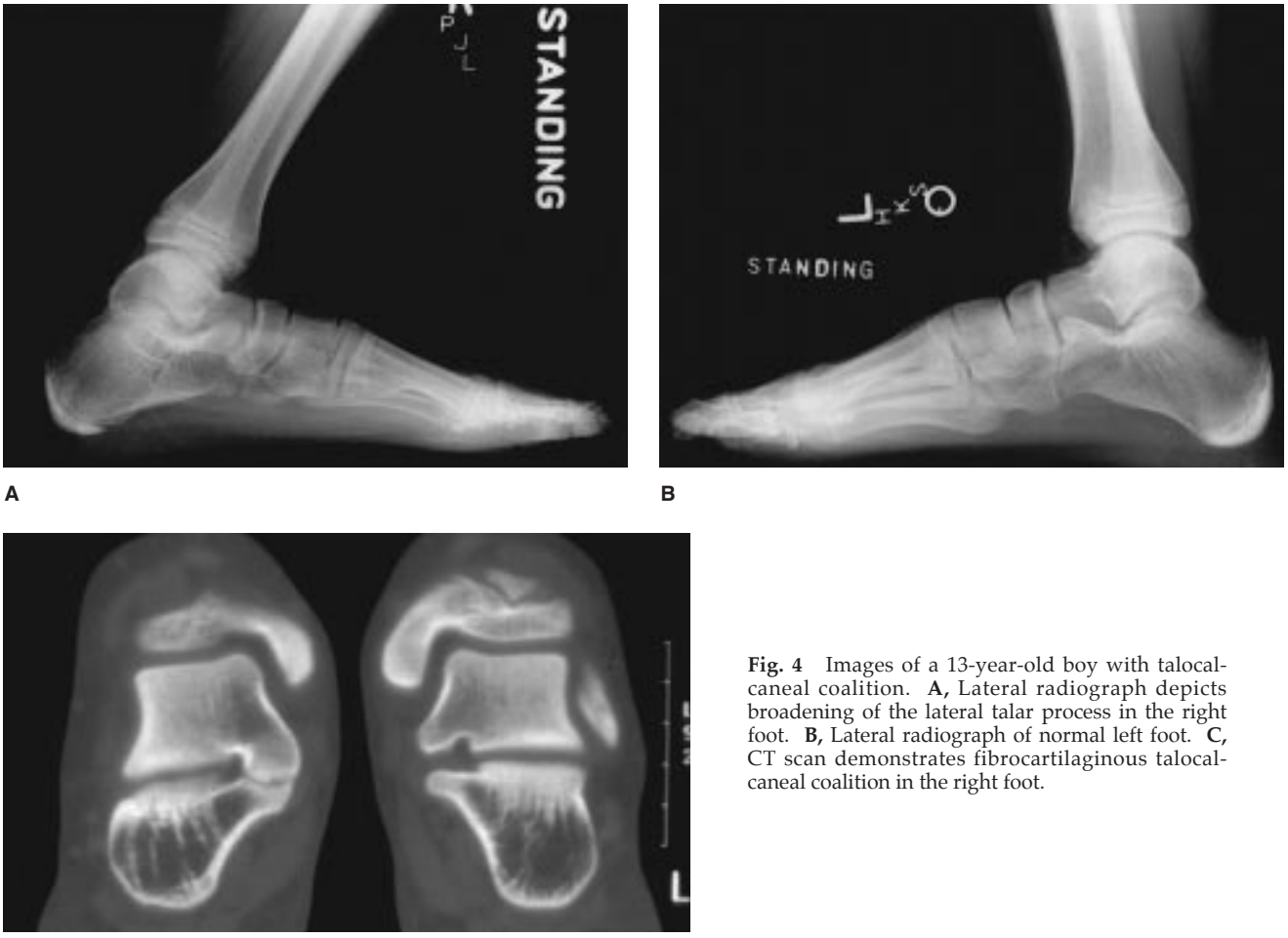

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Fig. 4 Images of a 13-year-old boy with talocalcaneal coalition. **A,** Lateral radiograph depicts broadening of the lateral talar process in the right foot. **B,** Lateral radiograph of normal left foot. **C,** CT scan demonstrates fibrocartilaginous talocalcaneal coalition in the right foot.

or a plantar surface button. A below-knee cast is used for 3 weeks with no weight bearing to allow some healing of the muscle transfer and abatement of inflammation. The cast is then removed, and mobility of the subtalar joint is encouraged.

Another surgical procedure that has been advocated for both common types of tarsal coalition is the lateral calcaneal opening-wedge osteotomy, as described by Cain and Hyman.[12] Pain relief was achieved in all 14 patients in their series. The procedure is designed to achieve more normal axial foot alignment and thereby reduce ligament strain. Because this procedure is not used widely for tarsal coalition, confirmation of results from other series has been difficult.

The role of subtalar arthrodesis in the treatment of calcaneonavicular coalition is not clear. Its use would seem to be most appropriate for the patient with a failed resection but minimal talonavicular arthrosis. This clinical situation is rare. Reported results in the literature have been only anecdotal.

Triple arthrodesis is usually the final choice for surgical treatment of the calcaneonavicular tarsal coalition. In the past, it was advocated at various times as the primary treatment mode for tarsal coalition. We have found it to be necessary only rarely in initial management. Its use should be reserved for the older patient (probably over 16) with radiographic evidence of relatively advanced degenerative changes. Pain relief can usually be obtained in the short term with use of triple arthrodesis, but postarthrodesis strain on the ankle and midtarsal joints may create symptoms from increased wear in the long term.

Surgical Treatment of Talocalcaneal Coalition

The indications for surgery in subtalar coalitions are the same as those for the calcaneonavicular coalition. The specific surgical

treatment of choice for talocalcaneal coalitions has been more controversial, however. The indications for subtalar arthrodesis alone are not clear and have not been reported on widely. Certainly, minimal talonavicular degenerative changes would be a prerequisite. Some authors have suggested that the initial surgical treatment should be triple arthrodesis rather than resection.[6] Harris[5] recommends exploration of the subtalar joint medially. If a solid coalition is present, he recommends fusion of the talonavicular joint but not the calcaneocuboid joint. If a partially mobile subtalar joint is found, he recommends fusion of the joint laterally and talonavicular arthrodesis.

One reason to consider triple arthrodesis is that patients are older at the time of diagnosis, and degenerative changes are therefore more advanced. Weight-bearing stresses across this joint, if freed for mobility, could be so great as to cause stress-related pain from the other (early degenerative) joints of the foot. In spite of these theoretical considerations, recent reports suggest successful results with resection of the middle-facet coalition with fat-graft interposition.[13,14] With the development of CT, precise localization of the coalition is possible. This imaging should allow more precisely directed surgery than has been possible with plain radiography or arthrography. In most cases, the preferred primary surgical treatment is now resection with fat grafting, rather than triple arthrodesis. This does not "burn bridges" for the possibility of a triple arthrodesis in the future, should pain relief not be adequate with the resection. The maximum amount of middle-facet involvement that should be considered for resection is not clear. A figure of 50% involvement or more has been discussed as a possible contraindication to resection. However, our approach has been to consider any amount of middle-facet involvement for resection, as long as some subtalar joint motion is restored.

The preferred technique for resection is to make a curved incision on the medial side of the foot and then to isolate the interval between the flexor digitorum longus and the neurovascular bundle. The flexor hallucis longus passes just plantar to the sustentaculum tali and traverses deep to the neurovascular bundle at the level of the coalition. The anterior and posterior portions of the coalition are identified with subperiosteal dissection, and the bridge of bone or cartilage is removed with an osteotome, a curette, or a rongeur. A relatively wide opening of at least 1 cm is created, bone wax is placed, and a fat graft is inserted into the defect.

To prevent recurrence, a below-knee cast with no weight bearing is used for 3 weeks to allow the graft to stabilize and inflammation to subside. After cast removal, weight bearing is allowed, and mobilization of the subtalar joint is encouraged. It is not clear what the eventual fate of the fat graft is, or if it is even necessary in the weight-bearing joint. A second postoperative routine to consider is early subtalar-joint mobilization and weight bearing.

Summary

Tarsal coalition is a congenital condition, probably inherited in an autosomal dominant pattern with nearly complete penetrance. Inheritance is not specific for the site within the foot. The most common sites by far are the calcaneonavicular joint and the middle facet of the talocalcaneal joint. The prevalence is probably about 1%.

The condition presents with what has classically been called the syndrome of peroneal spastic flatfoot, although muscle spasm is usually not a typical feature. Age at presentation ranges from the late juvenile stage through adolescence. Development of symptoms coincides with ossification, thus increasing rigidity of the foot with age. Disruption of subtalar joint motion results in changes in motion at the other joints within the foot, eventually resulting in degenerative changes.

The calcaneonavicular coalition is best demonstrated with a 45-degree oblique radiograph. The middle-facet (and other) talocalcaneal coalitions may be visualized on an axial plain radiograph of the heel, but are best seen on CT sections obtained in the plane perpendicular to the posterior facet of the subtalar joint. Secondary changes seen on lateral radiographs that may suggest presence of a tarsal coalition include talonavicular beaking, broadening of the lateral process of the talus, and a hypoplastic talar head.

Initial treatment of the two most common forms of tarsal coalition consists of conservative measures, including casting followed by orthotic use. If this should fail to relieve symptoms, surgery can be considered. The calcaneonavicular bar is resected from the lateral aspect, and the extensor digitorum brevis is interposed to prevent recurrence of bone formation. The talocalcaneal bar is resected from the medial aspect, with interposition of a fat graft. Triple arthrodesis should be considered a salvage procedure if resection fails to relieve symptoms, or if degenerative changes are advanced at the time of presentation.

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