# Detection of Talocalcaneal Coalitions by Magnification Bone Scintigraphy

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Fibrocartilaginous talocalcaneal coalitions are very difficult to identify on plain radiography in symptomatic children and adolescents before gross ossification occurs. Computed tomography (CT) has been successful in identifying osseous and some fibro-osseous coalitions. In this series, magnification imaging of the tarsus on bone scintigraphy in the medial-lateral projection correctly identified talocalcaneal coalitions, seven of the nine bars were fibrous or fibro-osseous. Three of the fibrous lesions were equivocal or normal on conventional radiography and CT. Physiologic accumulations of activity in the growing hind foot are also presented from a control pediatric population. Magnification scintigraphy of the hind foot is offered as an adjunct to plain radiography and CT in the diagnosis of elusive nonosseous subtalar bars (see Table 1).

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Subtalar coalitions can be difficult to identify clinically and radiographically. While "peroneal spastic flatfoot" has been a frequent clinical presentation of talocalcaneal coalition (*1,2*), some patients are asymptomatic and others have transient symptomatology. Good results with resection of talocalcaneal bars have been achieved when early recognition of symptomatic subtalar coalition permits surgery before the onset of secondary osteoarthritis. Triple arthrodesis, the surgical procedure performed in patients resistant to conservative therapy, may be avoided (*3*).

Routine anteroposterior, lateral, and oblique views of the foot are not able to demonstrate the entire middle facet (medial in location) of the subtalar joint. Historically, the success rate for identifying these congenital failures of mesenchymal segmentation by plain radiography is quite low. Complete osseous bridges are more readily detected by radiographs and the other imaging modalities. Even specialized axial projections of the hind foot defining the middle and posterior facets between the talus and calcaneus (Harris-Beath view) can be disappointing when it comes to revealing nonosseous coalitions (*2*). In one series reported prior to the advent of computed tomography (CT), only 4 of 23 spastic flat feet were identified radiographically as having talocalcaneal bars (*4*). In recent times, CT has been advocated for a more accurate determination of subtalar coalitions (*5–9*). However, even with CT, there are some instances, such as the presence of fibrous or cartilaginous bars in the adolescent or pre-adolescent, when CT results can be equivocal (*9*).

Bone scintigraphy has played a minor role in the diagnosis of talocalcaneal coalitions (*10*). Our recent experience with high-resolution magnification scintigraphy suggests a specific circumstance when this technique can be helpful (Table 1). We offer evidence that bone tracer uptake will be abnormal in fibrocartilaginous coalitions that are not conclusively identified by other imaging modalities.

## MATERIALS AND METHODS

Preoperative bone scintigraphy in 8 patients with surgically proven subtalar coalition was compared with foot scintigraphy in 12 control patients. Six patients with subtalar coalitions were reviewed retrospectively and two patients were diagnosed prospectively. These patients ranged in age from 7.8 to 18.6 yr with a mean age of 13.6 yr. The average duration of their clinical complaints, such as subtalar pain and restriction of foot motion, was 2 yr 7 mo. Five of nine of the patients were symptomatic bilaterally. All patients had plain film examinations consisting of anteroposterior, lateral, oblique, and Harris-Beath views. Computed tomography consisted of short-axis coronal views of the subtalar joints with 5-mm slice thickness with 3-mm spacing. The scanning was started at the most posterior portion of the posterior facet and was terminated in the mid-navicular bone. Both feet were placed in the gantry with knees bent and feet dorsiflexed. The lateral scout view was used to locate focus of transaxial imaging.

Bone scintigraphy, performed in all the patients, utilized technetium-99m-methylene diphosphonate (200 $\mu$Ci/kg) administered as an intravenous bolus. The study included early-phase (blood-pool) imaging in anterior and medial lateral projections as well as delayed imaging in anterior, medial-lateral, lateral-lateral, and plantar projections. In addition, medial-lateral magnification views were obtained by either pinhole collimation (seven patients) or electronic techniques (one patient). The pinhole aperture was 4 mm and the opening

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**TABLE 1**
**Algorithm For Fibrous Coalition Detection**

Radiographs (+) → Stop
(−) or (+/−) → CT (+) → Stop
(−) or (+/−) → Bone Scan with Magnification (+) → Stop
(−) → Treat Conservatively

+/− = equivocal.

was placed three finger breadths above the skin surface of the foot and 100,000 counts were acquired. The foot was positioned in a neutral position parallel to the table. The image of the talus and calcaneus was confirmed by the computer monitor. Electronically generated magnification views (2X) were made with a high resolution collimator and 250,000 counts were acquired.

The control population consisted of 12 patients (10 males, 2 females), who were having scintigraphy because of diverse complaints of ankle or leg pain. All of the patients had normal clinical exams of the feet and no history of specific foot problems. The control group data was obtained retrospectively in 7 patients and prospectively in 5 patients. It was the purpose of these images to confirm the normal scintigraphic appearance of the hind foot. The imaging technique was the same as described for the coalition patients. The medial-lateral magnification views consisted of pinhole images in six patients and electronically magnified views in six patients.

## RESULTS

In the eight patients with coalitions, we were able to evaluate 13 individual feet. One foot was excluded because of prior surgery, one asymptomatic foot was not radiographed, and the radiographs of one foot were missing. The radiographic signs found by Beckly to be associated with coalition were sought on the lateral radiographs of the symptomatic feet (*11*). Talar beaking was seen in none of the patients. A finding of obliteration of the middle subtalar joint (seven feet), rounding of the lateral process (five feet), flattening or concavity of talar neck (four feet), anterior subtalar joint space narrowing (five feet), or posterior subtalar joint space narrowing (five feet) was seen on the lateral view. The most common preoperative radiographic finding was the obliteration of the middle subtalar region. Harris views exhibited evidence of coalition in four feet. Lateral linear tomography was only performed in two patients, positive in one and equivocal in the other.

Bone scintigraphy in the control patients demonstrated no increased activity in the middle facet location on the blood-pool images. Areas of physiologic activity increased, but inconstant radiotracer uptake on the blood-pool images as well as delayed plantar images (to a greater degree) included the anterior talar junction with the posterior aspect of the navicular bone; the superior, anterior aspect of the calcaneus (Fig. 1); the confluence of the calcaneus, cuboid, and talus; and the posterior ossification center of the talus (the os trigonum) (Fig. 2B). The lack of separation of the talus and calcaneus is limited by the lack of high resolution. Magnification views usually separated the talus and calcaneus (particularly the pinhole images) but sometimes showed increased parallel activity along the talocalcaneal borders (Figs. 1, 2B, 3D). The peripheral cortical activity of the posterior half of the talus was seen in younger patients (Fig. 1).

In the tarsal coalition population, 15 feet (exclusion of one postoperative foot) were examined by bone scintigraphy. Medial-lateral magnification views usually

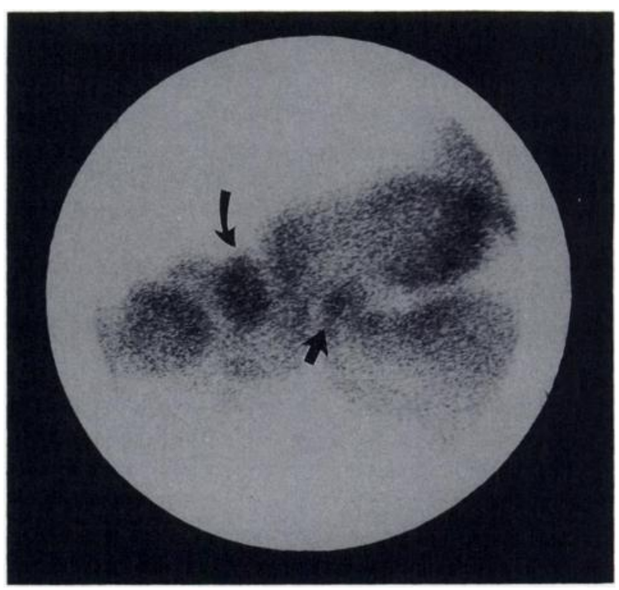

**FIGURE 1**
Medial-lateral magnification view with normal variations of increased activity in developing navicular bone (curved arrow) and anterior superior aspect of calcaneus (arrow).

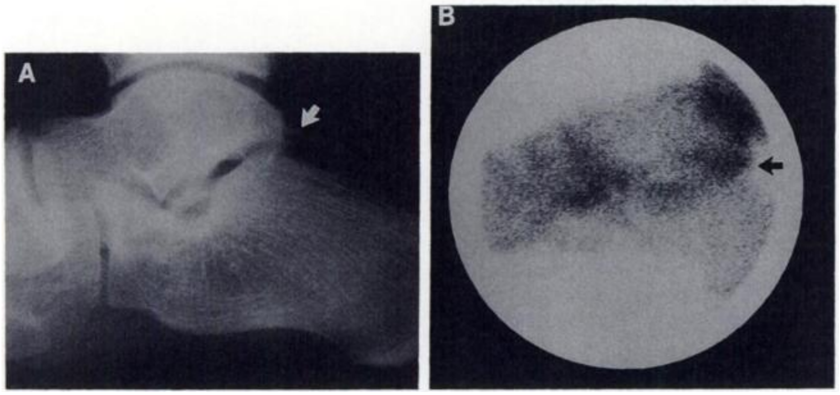


**FIGURE 2**
(A) Lateral radiograph demonstrating accessory apophyseal ossification center of dorsal process of talus (arrow). (B) Pinhole high-resolution magnification medial-lateral view demonstrating increased activity in os trigonum posteriorly (arrow).

demonstrated the bar to best advantage (Fig. 3E). Blood-pool images showed some diffuse increased uptake in the tarsus in 10 feet. There was more diffuse activity on the less symptomatic side on the blood-pool images in four patients, probably related to asymmetric usage of the lower extremities. The activity in the subtalar region (region of the middle facet) on the blood-pool images was increased in five of seven biopsy-proven nonosseous coalitions (Fig. 3B). Both surgerized osseous coalitions exhibited preoperatively increased uptake. Delayed planar images were suggestive of increased uptake in the middle facet region in 10 of 15 feet (Fig. 3C). Preoperative designation of increased uptake lateralizing to the fibrous coalition on planar

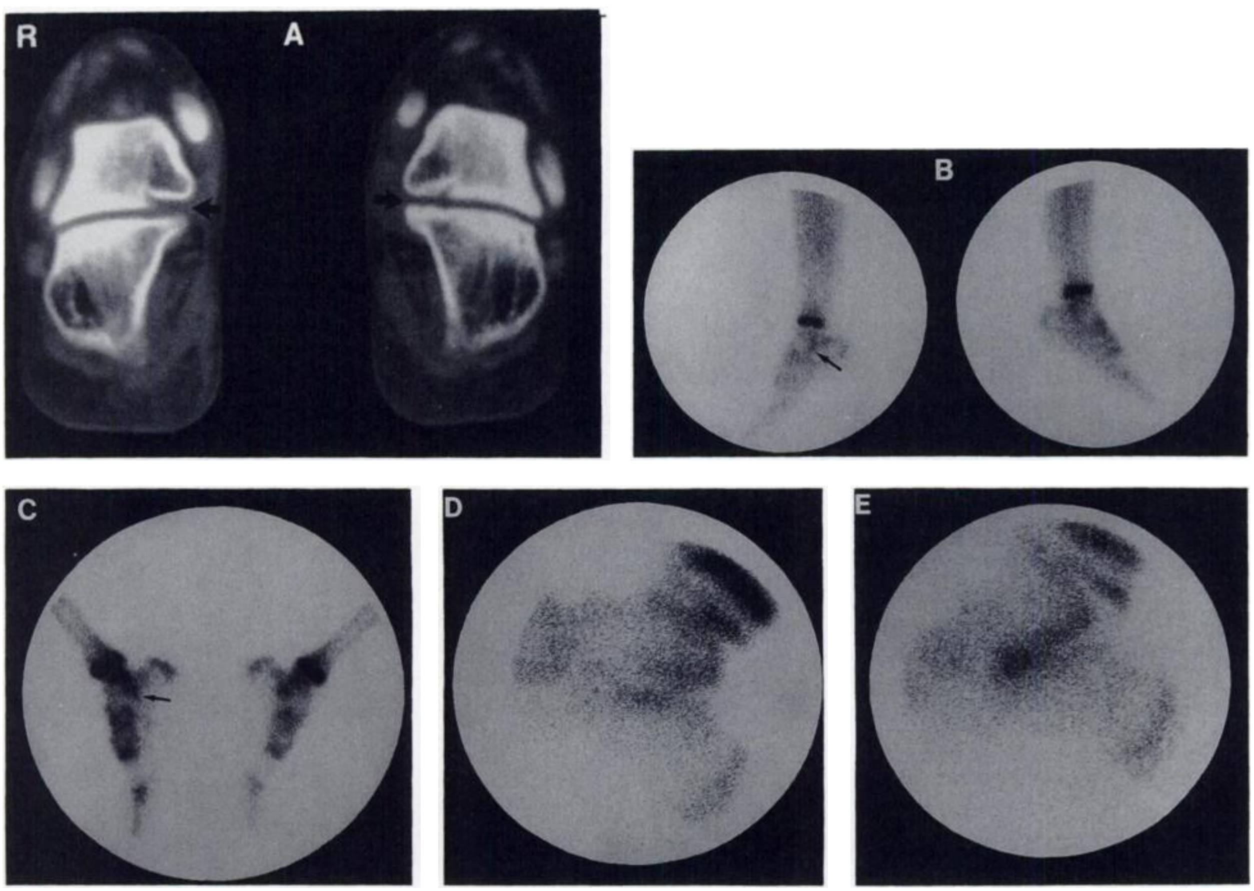


**FIGURE 3**
(A) Short-axis transaxial computed tomography of hind feet demonstrating normal middle facet on right (arrow) and suggestion at some irregularity and narrowing on left (arrow) but no osseous fusion. (B) Blood-pool medial-lateral images with slight increased uptake on abnormal left side in middle-facet location (arrow). (C) Delayed medial-lateral planar views with mild suggestion of extra uptake in middle-facet on left side (arrow). (D) Pinhole high-resolution magnification medial-lateral view of right foot with normal separation of parallel cortices of talus and calcaneus. (E) Pinhole high-resolution magnification medial-lateral view of left foot with increased activity at middle-facet location.

images was suggested in three of the seven operated cases. The two osseous coalitions with bone scintigraphy prior to CT were also identified prior to surgery with much more avid uptake of the radiopharmaceutical at the coalition site. In one patient, the bone scan was highly suggestive of an osseous coalition in one foot with definite confirmation by CT examination. The patient has not had surgery to this foot at the time of this reporting but had a previously resected osseous coalition on the contralateral side. Magnification (mainly a pinhole high-resolution) imaging demonstrated the most intense and exaggerated region of focal uptake in the middle facet in 11 feet (exclusive of one postsurgical foot, one symptomatic and three asymptomatic feet). In six patients, the greater activity in the subtalar region corresponded to the more symptomatic side. In one patient with bilateral surgically proven fibrous coalitions, the increased subtalar activity was bilaterally symmetrical. In another patient with bilateral surgically proven osseous coalitions, the more symptomatic side had slightly less activity.

Computed tomography demonstrated changes in the subtalar joint, mainly just behind the sustentaculum tali in the middle facet in five feet (two osseous fusions and three narrowing of joint) (Fig. 3A). Two feet were postoperative at time of CT study and three feet were normal and six equivocal on the CT examination. Surgery was performed on nine feet, all with preoperative bone scans, and eight feet with preoperative CT scans. Bone scan magnification imaging correctly identified all nine (two osseous and seven fibrous lesions). The most intense activity was seen in the two osseous coalitions but with careful interpretation, the subtle activity associated with fibrous bars could also be detected. If planar imaging was used alone, only five of nine coalitions (two osseous and three fibrous) would have been properly diagnosed by scintigraphy. The preoperative CT examination was correct in predicting coalitions in five feet (one osseous, four fibrous) but equivocal in another two feet.

## DISCUSSION

Congenital tarsal coalitions can be fibrous, cartilaginous or osseous. The talocalcaneal and calcaneonavicular synostoses are the most frequently occurring tarsal fusions. Almost all talocalcaneal coalitions involve the middle facet occurring just behind the sustentaculum tali. These congenital lesions are purported to be asymptomatic in early childhood with symptoms occurring, when appearing in the second decade, when the coalition intensifies. Our youngest patient, 7.8 yr, had osseous coalitions. In our series, fibrous bars were found in 78% of the operated cases. The average age for a fibrous coalition was 14 yr 2 mo while the average age for an osseous coalition was 12 yr 3 mo. Ankylosis of the posterior subtalar joint or of the anterior facets is far less common. The condition is more common in boys and is bilateral in 81% of patients (*1*). The mode of inheritance is probably an autosomal-dominant pattern with nearly full penetrance. Leonard showed that 39% of first-degree relatives of 31 patients had radiographically evident tarsal coalitions. These relatives, however, were asymptomatic (*1*). The classic presentation is a stiff, painful foot, accentuated by walking or standing. The "peroneal spastic foot" has been reported frequently with talocalcaneal coalitions (*2,3*). The pes planus foot is not always present, with a smaller percentage presenting with a cavus foot.

A number of secondary radiographic signs have been recognized on plain lateral radiographs in association with talocalcaneal coalition (*11*). Dorsal subluxation of the navicular bone produced by subtalar rigidity produces elevation of the periosteum below the talonavicular ligament with production of an osseous excrescence at the dorsal surface of the anterior portion of the talus, the so called "talar beak" (*10*). Beaking was not demonstrated in our tarsal coalition population. Talar beaking occurs late in the course of the disease and may not be ossified in the younger population. Narrowing of the posterior subtalar joint and broadening of the lateral process of the talus can sometimes be recognized as suggestive secondary signs 50% of the time. Not every secondary sign occurs in each foot. Posterior and middle facet subtalar regions were concurrently narrowed in three feet in our series. Harris views (axial views) of the hind foot can sometimes demonstrate the varying degrees of beam angulation in the complete or partial fusion of the medial subtalar joint (*2*). However, performing these views with the correct angulation for demonstration of the abnormality of the middle facet can be trying and difficult. The angulation can vary from patient to patient. In our series, the Harris view identified preoperatively only 50% of the coalitions. However, only a small percentage of talocalcaneal coalitions in children can be diagnosed by plain films (including Harris down views) (*2*).

Computed tomography usually allows determination of location, extent, and nature of coalition with visualization of all the facets in the transaxial projections (short-axis coronal views). Osseous coalitions are relatively easy to demonstrate by CT. The fibrous and cartilaginous bars are exasperating even with CT. In our series, CT afforded diagnosis in five of eight feet (40% of these were osseous). In reviewing the literature on CT diagnosis of tarsal coalition, either osseous or osseocartilaginous tissue have been readily identified with CT examination (*5–9*). No mention is made of fibrous bars, which are even more difficult to diagnose from plain radiographic films and CT. In another published series, nonosseous coalitions were identified on CT by a subtle irregularity or by an ill-defined posterior aspect of the sustentaculum tali (*9*).

Bone scintigraphy has been reported to show augmented uptake in the region of the subtalar joint with secondary activity in the region of the superior surface of the talus or in the superior aspect of the talonavicular joint (*10*). Usually, the areas of secondary reactive uptake are not as intense as the middle facet region. In Goldman's series, the augmented upper talar or talonavicular activity was seen in both osseous and fibrous coalitions (*10*). The magnification images are able to localize the area of increase in activity focally bridging the middle facet region. Pinhole images with their high-resolution demonstrate the coalition to best advantage.

Physiologic activity has also been described in our controls to occur in the anterior, superior aspect of the calcaneus, the posterior part of the talus, the talonavicular border, and the junction of the calcaneus, cuboid, and navicular bones. A quite common focus of increased uptake in our series, the accessory apophyseal ossification center of the dorsal process of the talus (posterior, inferior surface of the talus), begins to appear at 5–6 yr of age and fuses between 16 and 20 yr (*12*). Failure of fusion results in the separate ossicle, the os trigonum tarsi. The calcaneus secondarius is another area of physiologic increased activity on bone scan. It is a secondary ossification center lying between the calcaneus, talus, cuboid, and navicular bones. It is rarely visible radiographically before the age of 12 (*12*). However, scintigraphic evidence of a growth-plate can predate the presence of the ossification. At times, the posterior accessory ossification center of the talus can be equal to or more active than the site of coalition.

The differential diagnosis of localized abnormal subtalar concentration of the bone radiotracer includes juvenile rheumatoid arthritis, trauma, synovitis, chrondrolysis, infection and rarely tumor (chondroblastoma, osteoid osteoma) in the pediatric population. The nidus of an osteoid osteoma can usually be identified as arising from either the talus or calcaneus with the pinhole imaging. Previous descriptions of bone scintigraphy have not included high-resolution pinhole images of the talocalcaneal region. In our series, three equivocal cases on CT could be demonstrated by bone scintigraphy. All of these coalitions were fibrous in nature.

Magnification scintigraphy of the tarsus is reported as an adjunct to CT and plain radiography when the results of the examination are equivocal or negative in a patient with a strong clinical suggestion of a talocalcaneal coalition (Table 1). Scintigraphy appears to be sensitive for both fibrous and osseous coalitions. Early detection of the symptomatic coalition is important so that early successful treatment can be given.

## REFERENCES


1. Leonard MA. The inheritance of tarsal coalition and its relationship to spastic flat foot. *J Bone Joint Surg* 1974; 56B:520–525.
2. Harris RI, Beath T. Etiology of peroneal spastic flat foot. *J Bone Joint Surg* 1948; 30B:624–634.
3. Olney BW, Asher MA. Excision of symptomatic coalition of the middle facet of the talocalcaneal joint. *J Bone Joint Surg* 1987; 69A:539–544.
4. Musgrave RE, Goldner JL. Results of triple arthrodeses for rigid flat feet. *South Med J* 1956; 49:32–39.
5. Stoskopf CA, Hernandez RJ, Kelikian A, et al. Evaluation of tarsal coalition by computed tomography. *J Pediatr Orthop* 1984; 4:365–369.
6. Deutsch AL, Resnick D, Campbell G. Computed tomography and bone scintigraphy in evaluation of tarsal coalition. *Radiology* 1982; 144:137–140.
7. Herzenberg JE, Goldner JL, Martinez S, et al. Computerized tomography of talocalcaneal tarsal coalition: a clinical and anatomic study. *Foot Ankle* 1986; 6:273–278.
8. Smith RW, Weissman BN, Braunstein EM, et al. Computed tomography of the hindfoot. *Clin Orthop* 1983; 177:34–38.
9. Lee MS, Harcke HT, Kumar SJ, et al. Subtalar coalition in children: new observations. *Radiology* 1989; 172:635–639.
10. Goldman AB, Pavlov H, Schneider R. Radionuclide bone scanning in subtalar coalitions: differential considerations. *AJR* 1982; 138:427–432.
11. Beckly DE, Anderson PW, Pedegana LR. The radiology of subtalar joint with special reference to talo-calcaneal coalition. *Clin Radiol* 1975; 26:333–341.
12. Caffey J. *Pediatric X-ray diagnosis*, Seventh edition. Chicago: Year Book Med Publishers; 1978:1061–1067.