Eleven children with clinical and radiographic findings suggestive of nonosseous subtalar coalition were found to have fibrous bridges at the time of surgery. A second group of 14 children with similar clinical and radiographic findings is being conservatively treated at present. This series of children suggests that a common site of nonosseous subtalar coalition is found posterior to the sustentaculum tali. Diagnosis of nonosseous coalition requires careful examination with computed tomography, with attention to subtle changes in the hindfoot, particularly posterior to the sustentaculum tali.

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The radiographic diagnosis of subtal ar coalition has been a perplexing subject since its recognition as a cause of peroneal spastic flatfoot (1–4). Diagnosis in children is difficult until skeletal maturation has progressed to the point when osseous bridging can be demonstrated; this usually does not occur until adolescence. There are coalitions composed of incomplete osseous bridges. These nonosseous coalitions consist of fibrous and cartilaginous tissue.

The traditional radiographic examination, even when supplemented by the Harris-Beath view (4), fails to identify all cases of subtal ar coalition (4). Before the availability of computed tomography (CT), linear tomograms were used in confusing cases. CT provides more detailed cross-sectional anatomy of the subtal ar joint and has been advocated by other investigators (5–9). Bone scintigraphy has also been used (10,11).

In this report, we present new observations on the nature of subtal ar coalition in children. Our experience with multiple imaging modalities has led us to recognize nonosseous coalitions in locations that have not been emphasized in the recent literature. A properly performed CT study is the most effective technique that can aid in making the correct diagnosis.

ANATOMY

The obliquely oriented tarsal canal divides the subtal ar joints into anteromedial and posterolateral compartments (Fig 1A–1E) (12). The posterior extension of the tarsal canal ends posterior and lateral to the sustentaculum tali, which provides the strong platform for the middle facet joint. Hence, on coronal CT images, the facet medial to the tarsal canal is the middle or anterior facet, and the articulation lateral to the tarsal canal constitutes the posterior facet. This article will make specific reference to a location between the middle and posterior facets that is not part of either facet. This location is situated posterior to the sustentaculum tali and involves the posteromedial aspect of the tarsal canal and area anteromedial to the posterior facet. The anterior and middle facets may be separate or continuous (Fig 1D–1F) as one joint. Rather uncommonly, the anterior facet joint is a major weight-bearing joint, along with the posterior facet joint. In this situation, articulation at the middle facet does not occur, because the talon component of the joint fails to develop.

PATIENTS AND METHODS

The report group consists of two groups of children with clinical and radiographic suggestion of tarsal coalition. The first group of 11 children had undergone surgery that helped to confirm a subtal ar joint pathologic condition. The second group of 14 children, who have radiologic findings similar to those found in the surgical group, presently are being treated with nonsurgical methods. Four additional patients had a radiographically obvious bone coalition. These 29 children were aged 8–17 years. All patients had undergone a plain radiographic examination and a CT examination. Conventional radiography included standing anteroposterior, lateral, Harris-Beath, and supine oblique views. A model 8800 unit (GE Medical Systems, Milwaukee) was used for the CT studies. Both feet were placed in the gantry, with the knees bent and the feet slightly plantar flexed (14), and a lateral view was obtained. The gantry plane was set to be as perpendicular as possible to that of the general plane of the subtal ar joint by using the lateral ScoutView program. Scanning was started at the most posterior edge of the posterior facet joint and was terminated in the midnavicular bone. Each study consisted of coronal views of the subtal ar joints obtained at a 5-mm section thickness with 3-mm spacing. The images were constructed by using the bone algorithm.

Any previous radiographs and ancillary imaging examinations were re-
viewed. Lateral tomograms were available in 17 patients. The radiologic diagnosis of coalition by type and location was made on the basis of the CT appearance. Osseous coalitions consisted of complete bone bridging of the joint. Nonosseous coalitions consisted of soft-tissue bridges; two types were observed. One type showed only morphologic changes in the joint space, and these coalitions without a marginal cortical irregularity were called "fibrocartilaginous." A second type in which an irregular hypertrophic cortical reaction was noted at the site of bridging and joint space narrowing was called "fibroosseous." The distinction is emphasized because the fibrocartilaginous type is more difficult to identify.

The portion of the subtalar joint involved was described as multiple facets, the middle facet, or posterior to the sustentaculum tali. This last category is a specific focus of this report because it is a location distinct from the middle facet that is formed and open. Images were evaluated for the incidence and onset of talar beaking, the broadening of the lateral talar process, and the ability to visualize the middle facet joint on the standing lateral view (15). Medical records were reviewed to correlate the occurrence of pereoneal spasm, reduced subtalar motion, and flatfoot.

RESULTS

In the group of 11 children who underwent surgery, the preoperative determination of coalition was made on the basis of the changes seen on CT and lateral tomographic examinations. Confirmation at surgery was made with direct visualization of the subtalar joint and changes in motion after release of any bridging tissue. In the four patients with multiple-facet involvement, the bridges were of the fibroosseous type, and the changes were easy to recognize on plain tomographic images. The hypertrophic osseous changes at the cortical margins accompanied the narrowing of the subtalar joint. At the time of surgery, the bridging tissue was described as fibrous in nature. In the two patients with middle-facet coalition, there was one instance of fibroosseous bridging (Fig 2) and one instance of fibrocartilaginous bridging that lacked the hypertrophic bone reaction (Fig 3). Figure 4 is one example of an obvious fibroosseous-type coalition located posterior to the sustentaculum tali. In five patients, fibrocartilaginous bridging occurred posterior to the sustentaculum tali (Figs 5, 6). In these patients, CT enabled distinction of coalition more posterior to the sustentaculum tali from middle facet coalition. When bridging involved this area at the posterior margin of the tarsal canal, it occurred without clo-
Figure 3. Images of an 11-year-old girl. Surgically confirmed middle-facet coalition, fibrocartilaginous type. Lateral tomogram (a) and coronal CT section (b) of the same foot (b) show only irregular bone margin with no hypertrophic bone reaction as seen on Figure 2 (arrow).

Figure 5. Images of 14-year-old boy. Surgically confirmed fibrocartilaginous coalition was found posterior to the sustentaculum tali. Harris view (a) and coronal CT section (b) reveal hypoplastic sustentaculum tali (arrow) and an open middle and posterior facet joint. L = left, R = right.

Figure 6. Images of a 12-year-old boy. Surgically confirmed nonosseous fibrocartilaginous coalition located posterior to the sustentaculum tali. Lateral tomogram (a) and coronal CT sections (b) with off-axis reconstruction show an ill-defined posterior aspect of tali (arrow). Note hypoplastic tali on CT images.

Several findings associated with a nonosseous coalition, fibrocartilaginous type coalition. The sustentaculum tali were malformed and hypoplastic; this could be seen on the Harris view (Fig 5a) and the CT scan (Fig 5b). On CT scans or lateral tomograms, the articular surface showed a subtle irregularity or an ill-defined posterior aspect of the sustentaculum tali (Figs 3, 6). Use of off-axis CT reconstruction was helpful and showed changes that could also be found on lateral tomograms (Figs 2, 4, 6). Narrowing of the posteromedial end of the tarsal canal was a common CT finding in patients with fibroosseous coalition, especially where there was multiple facet involvement (Fig 2).

The literature reports an occurrence of subtalar coalition in one-third of patients with calcaneonavicular bars (3,16). Our finding of a calcaneonavicular bar in five of the 29 patients with subtalar coalition shows that coalition posterior to the sustentaculum tali occurs independently most of the time.

DISCUSSION

We wish to emphasize the occurrence of coalitions posterior to the sustentaculum tali; these were de-
scribed by Harris (17) more than 30 years ago and reported by the anatomist Pitzner (18) in 1896. In addition, we wish to focus on the ability of CT to facilitate the diagnosis of two types of nonosseous coalition: fibrososseous and fibrocartilaginous. The diagnostic dilemma of subtalar coalition was mentioned in 1955 by Harris (17), who first described the Harris-Beath view for radiographic demonstration (4) of subtalar coalition. This technique, however, is not ideal for the depiction of coalition located posterior to the sustentaculum tali, as the x-ray beam simply penetrates the coalition (Fig 7). The lateral tomographic views suggested by Conway and Cowell (19) often fail to include the sustentaculum tali because of the examiner’s unfamiliarity with the anatomy of the subtalar joint and unawareness of coalition posterior to the sustentaculum tali. The positive surgical and CT findings in our groups confirm the relatively common occurrence of coalition at this site and indicate the need to direct attention to this location at CT evaluation. The CT examination of the hindfoot in the coronal plane readily demonstrates the subtle changes of nonosseous coalition. One can be confident of the diagnosis of the fibroosseous type, as there is a hypertrophic bone reaction that accompanies the fibrous bridging (Figs 2, 4, 7b). The diagnosis of nonosseous bridging by fibrocartilage is only more difficult to determine with a CT scan; it is important to recognize the secondary signs of a deformity that accompany the bridging. The hypoplasia of the sustentaculum tali was described (Figs 5, 6), and, in some cases, there were subtle irregularities in the articular surface of the middle facet (Fig 3). In two of the surgically confirmed cases of fibrocartilaginous coalition posterior to the sustentaculum tali there was an ill-defined posterior aspect of the sustentaculum tali (Fig 6).

Talar beaking, peroneal spasm, planovalgus configuration, failure of depiction of the middle facet joint on the lateral view, and broadening of the lateral process of the talus are clinical and radiographic findings associated with subtalar coalition (4,15,20). In reviewing our entire series of patients, obvious talar beaking was present in only 11 of the 29 patients at the time of the first visit. Three patients have developed visible talar beaking on follow-up visits during a 2-3-year period. No patient younger than 10 years of age showed talar beaking. Five patients had an irregularity of the talar head at the talonavicular joint. The clinical examination revealed a classic peroneal spasm in eight patients; however, limited or reduced subtalar passive motion was a common clinical finding in all patients. Twenty of the 29 patients had a flatfoot deformity, three had a cavovarus deformity, two had a forefoot varus deformity, two had a forefoot valgus deformity, and two had normal bone alignment. Slight rotation of the hindfoot on the lateral projection is subject to overinterpretation as broadening of the lateral talar process because the process is sharp on one edge and has a rounded appearance on the other. When the hindfoot is inverted or everted, the subtalar joint space often is obscured on the lateral projection, and the middle facet joint appears to be open, especially when coalition occurs posterior to the sustentaculum tali.

Because the previously described radiographic signs of subtalar coalition, such as talar beaking, may or may not be present in the feet of preadolescent children with subtalar coalition, pain and limited subtalar motion become the indications for careful investigation of the subtalar joint. Recommended studies for subtalar coalition in children begin with plain radiography, to include standing anteroposterior, standing lateral, oblique, and Harris-Beath views. CT examination, by using a 5-mm section thickness with 3-mm spacing in the coronal plane of the foot extending from the most posterior part of the posterior facet to the midnavicular bone, will help to reveal the coalition. Lateral tomography and bone scanning can be reserved for selected patients in whom additional information is required subsequent to inconclusive CT results. ■
References