The Presence of Calcaneal Fibular Remodeling Associated With Middle Facet Talocalcaneal Coalition: A Retrospective CT Review of 35 Feet. Investigations Involving Middle Facet Coalitions—Part II

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Middle facet talocalcaneal coalition is often associated with a rigid pes planovalgus. In the presence of calcaneal valgus, the fibula may come into contact with the lateral calcaneal wall during weight bearing, and develop a pseudoarticulation. Spurring, bone cysts, and other morphologic changes may concomitantly occur at the calcaneus and fibula, suggesting a pathological degenerative process. This association has not been previously studied in middle facet tarsal coalition and we term the condition calcaneal fibular remodeling, the focus of this investigation. To our knowledge, no study has specifically looked at the abutment of the calcaneus and fibula as an additional area of pathology in patients treated operatively for tarsal coalition.

Computerized axial tomography was retrospectively reviewed in 21 patients (35 feet) with symptomatic middle facet talocalcaneal coalition who were surgically treated for the coalition on at least 1 foot over a 12-year period. In 19 (54%) of the 35 feet, calcaneal fibular remodeling was identified and associated with concomitant coalition and pes planovalgus deformity. Fifteen (79%) of the 19 feet with calcaneal fibular remodeling were managed surgically at the time of manuscript submission for middle facet talocalcaneal coalition. This new finding suggests that simple resection of the coalition may not fully address the entire deformity and other combined surgical approaches may be more appropriate in the face of middle facet talocalcaneal coalition with heel valgus and calcaneal fibular remodeling. Level of Clinical Evidence: 4 (The Journal of Foot & Ankle Surgery 47(4):288–294, 2008)

Key Words: tarsal coalition, calcaneal fibular remodeling, pes planus, middle facet talocalcaneal coalition

Painful middle facet talocalcaneal coalition (TCC) is often associated with a rigid pes planovalgus. Recent literature has questioned the source of the associated symptoms, which may be related to the coalition itself, or instead, to the pes planovalgus (1–4). Three separate investigators demonstrated that simple resection alone in the presence of heel valgus resulted in poorer outcomes, suggesting that the calcaneal valgus contributes to the painful condition (1, 2, 5). Moreover, single-stage middle facet coalition resections combined with flatfoot reconstruction demonstrated successful outcomes in a small series, further implicating the pes planovalgus as part of the pathological process (4, 6).

It is not entirely clear what aspects of the calcaneal valgus result in pain when associated with middle facet coalition. Some investigators implicated an associated peroneal spasm (2, 7–10). Others have also advocated advanced imaging in an attempt to identify arthrosis in the rearfoot complex that may exist concurrently with the coalition (2, 4, 10–12). To our knowledge, no study has specifically looked at the abutment of the calcaneus and fibula as an additional area of pathology in coalition associated with flatfoot.

Depending on the severity of hindfoot valgus, the fibula abuts against the fixed calcaneus and a pseudoarticulation may develop (12). Spurring, cysts, and other morphologic changes may concomitantly occur at the calcaneus and fibula, suggesting a pathological degenerative process (see Figures 1–6). This association has not previously been studied in tarsal coalition. We term the condition calcaneal...
fibular remodeling (CFR), the focus of this investigation. The presence of CFR may contribute to the symptoms associated with painful TCC, which may provide a clearer indication that simple resection of the coalition may not fully address the entire deformity and other combined surgical approaches may be more appropriate in the face of TCC with heel valgus and CFR.

**Materials and Methods**

A retrospective review of 12 surgeons’ logs for patients who had middle facet TCC identified on preoperative computerized axial tomography (CT), and treated by surgical management over a 12-year period was performed. Surgical management of the TCC was defined as operative intervention that may have included one of the following procedures: simple resection of the coalition, rearfoot arthrodesis, or combined single-stage flatfoot reconstruction with middle facet coalition resection. We identified 21 patients with preoperative CT scans of middle facet TCC who had at least one foot surgery for coalition management. If a patient was found to have bilateral middle facet TCC on CT, and only 1 foot was operated on, then the contralateral nonsurgically treated foot was also included in this review. Thirty-five feet in 21 patients fulfilled these inclusion criteria.

In each patient, CT scans were obtained at the surgeon’s institution and reviewed by both authors electronically. All CT scans used slice width between 1 and 4.5 mm with a mean of 2.4 mm. The CT scans were evaluated for the presence of middle facet TCC, as well as the presence of middle facet TCC on the contralateral foot. Coalitions were defined by significant joint irregularity (consistent with a fibrous coalition) or trabecular bridging at the middle facet (consistent with an osseous coalition) from the talus to the
calcaneus. The presence of CFR was confirmed by using the same CT scans used for coalition evaluation. In all instances, the identification of CFR was most easily identified on the coronal CT slices at or about the level of the middle and posterior facets of the subtalar joint. CFR was defined by the presence of a valgus heel coupled with at least 2 of the following 3 criteria: eburnation, subchondral cysts, or morphologic changes in the calcaneus, fibula, or both. The presence of heel valgus was determined by evaluating tibial calcaneal bisections on coronal CT scans. In all cases, CFR was present only if there was concomitant heel valgus.

Results

The patient demographics, site clarification, CT data, and surgical confirmations are reviewed in Table 1. Coronal CT scans depicting CFR are displayed in Figures 1 to 6. Twenty-one patients with 35 feet met the inclusion criteria. Eleven patients (52.4%) were male and 10 (47.6%) were female with an average age of 20.2 years. There were 21 (60%) left feet and 14 (40%) right feet. Two thirds of the sample (14 patients) had bilateral coalition identified. Seven patients had unilateral coalition.

CFR was identified in 11 (52%) of the 21 patients, or 19 (54%) of 35 feet, and in all cases the CFR was present concomitantly with middle facet TCC and a valgus heel bisection. Eight of these patients (73%) with CFR had the condition bilaterally. Of the remaining 3 patients with CFR, 2 had unilateral TCC and 1 had bilateral TCC. Of the 2 patients with unilateral TCC and CFR the contralateral extremity had not been evaluated by CT scan so a diagnosis of CFR could not be confirmed or denied. Fifteen (79%) of the 19 feet with CFR were treated surgically for their concomitant middle facet TCC.

Discussion

Middle facet tarsal coalitions are common causes of rigid flatfeet in children and adolescents (7, 13–15). In a literature review spanning 50 years, Stormont and Peterson (15) found that 314 tarsal coalitions had been reported and 48% involved the talocalcaneal complex, with the majority of those involving the middle facet. They may occur unilaterally or bilaterally in as many as 50% of cases (9, 15–17), although in our series the incidence of symptomatic bilateral coalition with at least 1 foot treated surgically was 67%, and the incidence of bilateral coalition when CFR was present was even greater. Tarsal coalitions frequently go unrecognized because the symptoms tend not to appear until mid to late adolescence (14, 18). As a result, patients may develop peroneal spastic flatfoot and secondary degenerative arthritis of the rearfoot complex (8, 9), but no article has studied the pseudoarticulation between the fibula and calcaneus in this patient subset that we are aware of. Furthermore, until now no author has identified CFR as a potential part of the pathological process associated with TCC and pes planovalgus deformity in such a large cohort of surgically managed patients analyzed through CT scans.

Recent literature has questioned the source of the associated symptoms, which may be related to the coalition itself, or instead, to the pes planovalgus (1, 3, 5, 6). Part I of this series emphasized the concomitant single-stage correction of pes planus associated with middle facet TCC. It has been previously illustrated by at least 3 separate investigators that in the presence of heel valgus, simple resection of the TCC may result in poorer outcomes if the flatfoot is not addressed (1, 5, 6). Mosca (3) identified separately in his article on calcaneal lengthening for symptomatic flatfoot and skewfoot deformity, that 1 patient required a staged correction of flatfoot for persistent pain after an isolated TCC resection.

This part of our series (Part II) identifies a component of tarsal coalition and pes planus that, to the best of our knowledge, has never before been correlated on CT: calcaneal fibular remodeling. Diagnosed best on coronal CT slices, CFR refers to remodeling present at the lateral calcaneus and distal fibula that is likely secondary to a fixed heel valgus leading to consistent pathological contact be-
tween the 2 bones. In a pediatric patient with a congenital fixed coalition and calcaneal valgus, the axial loads may be transferred laterally into the fibula and onto the calcaneus, resulting in CFR.

It appears that less severe CFR takes the form of eburnation and sclerosis at the superolateral wall of the calcaneus as it is forced to articulate with the distal lateral malleolus. In later stages of CFR, or more advanced CFR, cysts may be found in the calcaneus and fibula that may communicate with the developing false articulation between the 2 bones, as Landells (19) describes in his treatise on bone cysts in osteoarthritis. However, Landells was discuss-

FIGURE 3 CFR associated with TCC in a skeletally immature 11-year-old girl (TCC is not visualized on these sections). Heel valgus is present along with eburnation at the superolateral wall of the calcaneus where the fibula abuts the calcaneus. A large plantar calcaneal cyst is intimately associated with the eburnation (asterisks). A fibular cyst is present as well, unilaterally (white arrow).

FIGURE 4 Bilateral CFR and heel valgus associated with bilateral middle facet TCC in a skeletally immature 12-year-old male. Note the cystic areas within the bilateral plantar lateral calcaneus (asterisks), eburnation at the superolateral calcaneal wall (inferior to arrows) and slight peri-articular lipping (arrows) at the most superior portion of the lateral calcaneus.
ing periarticular cysts and we identify cysts associated with a pseudoarticulation. In end-stage remodeling, or severe CFR, there are significant morphologic changes in the calcaneus and distal fibula that fully resemble the assembly of an errant articulation between these two bones. Similar to a false ball and socket joint, the calcaneus may develop an acetabulum at its superolateral wall (Figure 1) to accommodate for the lateral malleolus being driven inferiorly with weight-bearing axial loads.

The etiology of CFR appears to be the rigid pes planovalgus, which is frequently secondary to the tarsal coalition. In other words, the etiology of CFR is a reflection of the calcaneal valgus and ground reactive forces that are lateral to the sagittal bisection of the ankle. Hansen (12) identified
that “The difference between ‘good’ and ‘bad’ flatfoot lies in the alignment of the foot in relation to the weight-bearing line of the leg. In general, a symptomatic foot lies lateral to the weight-bearing line of the leg and demonstrates both intrinsic bony malalignment (due to damage or stretching of the ligament) and muscle imbalance (usually gastrocnemius or gastrocsoleus equinus).”

Many authors have identified peroneal spasm as a source of pain and disability that has been associated with tarsal coalition (7, 8). We suspect that, in some cases, the lateral rearfoot pain associated with peroneal spasm may instead be part of the sequela of the peroneal tendon entrapment at the pseudoarticulation between the calcaneus and fibula with axial weight-bearing loads. Furthermore, in the setting of symptomatic TCC, some surgeons have associated the diffuse rearfoot pain with calcaneocuboid, talonavicular, or talocalcaneal arthrosis, when in fact it may be the pain associated with CFR. In some cases involving the subtalar joint, double or triple arthrodesis has been recommended for the management of peroneal spasm and/or talocalcaneal coalition that may have been associated with CFR. Unfortunately, long-term studies on the fusion of essential joints have demonstrated significant devolution of arthrosis in the remaining joints of the foot (20, 21). Is it possible that in some instances the hindfoot joints may be spared (rather than fused) for the management of TCC? In the absence of significant subtalar joint arthrosis, perhaps an alternative option for the management of TCC with concomitant CFR is to restore the weightbearing axis of the leg and the foot by a single-stage flatfoot reconstruction coupled with middle facet coalition resection (4). The goals of this combined reconstructive procedure would include alleviation of the potential peroneal tendon impingement, restoration of normal hindfoot architecture by bringing the calcaneus under the tibia, and perhaps prevention of CFR exacerbation.

With CFR it is unclear if there is a progressive remodeling with weight-bearing loads where the spurs and cysts lead to collapse into the lateral calcaneal wall. It is unclear if the eburnation begins first followed by the spurs and cysts or vice versa. It is also unclear if the degree of calcaneal valgus plays the most important role in determining the severity of CFR, although these authors believe this may be the case. In any event, we identified CFR in about half the patients (52%) who were treated operatively for middle facet coalition, and CFR consistently presented in a triad with TCC and heel valgus. Furthermore, 15 (79%) of the 19 feet with CFR were managed surgically at the time of manuscript submission for middle facet TCC.

Varner and Michelson (22) retrospectively reviewed 32 feet in 27 adults with the diagnosis of tarsal coalition seen at The Johns Hopkins Hospital Foot and Ankle Clinic over a 5-year period. Although they used CT scans for analysis of the deformity, they did not seem to identify the CFR, which we describe in this article. Taniguchi et al (23) retrospectively reviewed 19 CT scans in 55 feet with coalition. Nowhere in their study did they identify CFR either. Given the paucity of evidence-based medicine on this topic, future studies specifically looking at CFR would be beneficial.

There were limitations to this study. For one, there were variations in slice width between some of the CT scans, although the average slice width across all examinations was only 2.4 mm. Also, because some of the CT scans were completed at different institutions there may be subtle differences between the scans. In evaluation of CFR there may have been observer bias and/or error. In all cases, the presence of CFR was evaluated by both authors. We attempted to use objective criteria in evaluating for the presence or absence of CFR. The presence of eburnation, in particular, was more difficult to assess and this did pose a challenge for our objective criteria. Furthermore, because this was a retrospective study evaluating CT scans over a 12-year period at numerous

### TABLE 1 Patient data

<table>
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<tr>
<th>Patient</th>
<th>Age* and Sex</th>
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<th>CT Width, mm</th>
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Abbreviations: CFR, calcaneal fibular remodeling; F, female; L, left; M, male; n, no; R, right; TCC, talocalcaneal coalition; y, yes.

*Age at time of computed tomography (CT).
locations, the quality and techniques of scans varied and clinical charts were not always available. This precluded a consistent method for evaluating the exact degree of heel valgus. In this study, the inference was made that all feet were symptomatic because all feet in this retrospective review were evaluated by CT and 28 of the 35 feet had surgery. It is possible, however, that the 7 feet that were not treated surgically for TCC were not symptomatic, although they were scanned by CT, which suggests otherwise. Furthermore, it is possible, although unlikely, that there were feet in this study that were not symptomatic despite the fact that they were treated operatively. Because this was a retrospective study and CFR was identified secondarily, there is no way to clearly know if the CFR was a direct source of symptoms. Only a prospective study targeting CFR would better correlate its clinical significance. While the morphologic changes are somewhat obvious on the CT images, it is possible that CFR may not be directly associated with the patients’ “symptoms” at all. However, these morphologic changes associated with heel valgus surely suggest a pathologic process, especially in the context of TCC with concomitant flatfoot. This is particularly poignant when considering that a large majority (79%) of those feet with CFR had surgery to treat their concomitant symptomatic middle facet TCC. This does not necessarily suggest that CFR was the cause or need for surgery, but rather that it may play a role in the symptoms associated with the condition.

Conclusion

Talocalcaneal middle facet coalitions are known to produce a rigid pes planovalgus that often requires surgical intervention. Unfortunately, there is a lack of evidence-based medicine defining the pathophysiology behind the symptomatic middle facet TCC altogether. This retrospective CT review presents the largest cohort of patients treated surgically for symptomatic talocalcaneal coalition that the authors are aware of to date. In this review, we identify a pathological component of middle facet TCC associated with calcaneal valgus; titled calcaneal fibular remodeling. In this cohort of 35 feet, CFR was present in about half (52%) of the patients treated surgically for middle facet TCC. The presence of CFR may contribute to the symptoms associated with painful middle facet TCC. The morphologic changes associated with CFR provide a clearer indication that simple resection of the coalition may not fully address the entire deformity and other combined surgical approaches may be more appropriate in the face of middle facet TCC with heel valgus and CFR.

References