Talocalcaneal Tarsal Coalitions and the Calcaneal Lengthening Osteotomy: The Role of Deformity Correction

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Investigation performed at Seattle Children's Hospital, Seattle, Washington

Background: Surgical resection of persistently painful talocalcaneal tarsal coalitions may not reliably relieve symptoms in patients with large coalitions associated with excessive hindfoot valgus deformity and subtalar posterior facet narrowing. Since 1991, calcaneal lengthening osteotomy, with or without coalition resection, has been used at our institution to relieve symptoms and to preserve motion at the talonavicular and calcaneocuboid joints.

Methods: We retrospectively reviewed the records for eight patients with thirteen painful talocalcaneal tarsal coalitions who had undergone a calcaneal lengthening osteotomy for deformity correction with or without coalition resection between 1991 and 2005. Preoperative and postoperative clinical, radiographic, and computed tomographic records were reviewed. The duration of clinical follow-up ranged from two to fifteen years.

Results: Calcaneal lengthening osteotomy fully corrected the valgus deformity and provided short-to-intermediate term pain relief for the five patients (nine feet) in whom the talocalcaneal tarsal coalition was unresectable. The patient with resectable coalitions but excessive valgus deformities underwent calcaneal lengthening osteotomies along with coalition resections and had excellent deformity correction and pain relief in both feet. One of the two patients who underwent calcaneal lengthening osteotomy years after coalition resection had excellent correction and pain relief. The other patient had a coincident calcaneonavicular coalition and severe degenerative arthritis in the talonavicular joint. He underwent concurrent arthrodesis of the talonavicular joint and, although he had excellent deformity correction, had persistent pain. All feet underwent concurrent gastrocnemius or Achilles tendon lengthening.

Conclusions: It is generally accepted that resection is the treatment of choice for an intractably painful small talocalcaneal tarsal coalition that is associated with a wide, healthy posterior facet and minimal valgus deformity of the hindfoot. Although triple arthrodesis has been recommended for those who do not meet all three criteria, the present study suggests that an algorithmic treatment approach is justified. Treatment of the valgus deformity appears to be as important as that of the coalition. Calcaneal lengthening osteotomy with gastrocnemius or Achilles tendon lengthening is effective for correcting deformity and relieving pain in rigid flatfeet, just as it is in flexible flatfeet.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

Tarsal coalitions have a reported prevalence of 1% to 2%, although a recent cadaveric study demonstrated a prevalence of 13%. Middle facet talocalcaneal coalitions account for approximately 45% of all tarsal coalitions. Tarsal coalitions typically cause gradual flattening of the longitudinal arch and stiffness of the subtalar joint between the ages of eight...
and sixteen years. These clinical findings are not, however, the indication for treatment. Pain, which is present in only about 25% of feet with a tarsal coalition, is the consensual indication for treatment. The senior author (V.S.M.) has observed that pain can be experienced at one or more locations, including the site of the coalition, the ankle joint, the Chopart (talonavicular and calcaneocuboid) joints, the sinus tarsi, and medially under the head of the plantar-flexed talus. Pain at the site of a fibro-cartilaginous coalition implies inflammation at or adjacent to the coalition. Pain in the ankle joint or Chopart joints implies stress-transferred inflammation in those joints. Finally, pain under the head of a plantar-flexed talus or in the sinus tarsi is characteristic of a flatfoot in a patient with a tight Achilles tendon.

The treatment of middle facet tarsal coalitions has evolved over time. As the goal of treatment is to relieve pain and not simply to eliminate the coalition, the initial recommended treatment is nonoperative. Surgery is indicated when nonoperative treatment fails to relieve pain. Early reports recommended treatment with triple, double, or isolated subtalar arthrodesis. More recently, authors have reported good short-term results after talocalcaneal coalition resection. Most researchers have focused solely on coalition size as the predictor for a good outcome following resection. Beginning in 1987, the upper limit for successful resection was considered to be a coalition involving <50% of the surface area of the entire subtalar joint, although that criterion was established arbitrarily. The most recently proposed criteria include a middle facet coalition that, on computed tomographic (CT) scanning, involves <30% to 50% of the surface area of the posterior facet, with <16° to 21° of hindfoot valgus (measured on a coronal image), and with minimal or no narrowing or degeneration of the posterior facet of the subtalar joint. The relative importance of each of these features to the success of coalition resection, or overall treatment in general, has not been established. With most authors recommending either resection of the coalition or triple arthrodesis as the only treatment options, decision-making remains a problem when all three criteria do not indicate one option or the other.

Several authors have addressed the importance of the valgus deformity of the hindfoot. Anterior and posterior calcaneal osteotomies have been used for tarsal coalitions, but indications have not been clarified and no large, focused series has been reported. It has been the impression of the senior author (V.S.M.) that the site or sites of pain and the severity of valgus deformity are most important, since 1991, calcaneal lengthening osteotomy has been utilized to correct hindfoot valgus deformity in patients with painful and rigid flatfeet.

**Fig. 1**
Lateral radiograph showing the talar-first metatarsal angle (T-1MT), the talar-horizontal angle (T-H), and calcaneal pitch (CP). (Reproduced from: Mosca VS. Calcaneal lengthening for valgus deformity of the hindfoot. Results in children who had severe, symptomatic flatfoot and skewfoot. J Bone Joint Surg Am. 1995;77:500-12).

**Fig. 2**
Coronal CT scan showing a large osseous middle facet talocalcaneal tarsal coalition. The posterior facet is much more narrow (thinner) than the ankle joint, and there is excessive hindfoot valgus deformity.
performed in sixteen feet in eleven patients. Three distinct groups were ident-
ified: Group 1 included six patients (ten feet) who were managed with cal-
caneal lengthening osteotomy with no surgery involving the middle facet 
coalition, Group 2 included one patient (two feet) who was managed with 
simultaneous calcaneal lengthening osteotomy and resection of the middle 
facet coalition, and Group 3 included four patients (four feet) who were 
managed with calcaneal lengthening osteotomy at some time after the resection 
of a middle facet tarsal coalition in a foot with persistent pain and deformity 
(see Appendix). Demographic data, medical comorbidities, previous operative 
procedures, preoperative foot pain (presence and location), activity level, and 
operative procedure were collected retrospectively from the patient charts. A 
preoperative American Orthopaedic Foot & Ankle Society (AOFAS) ankle-
hindfoot score was estimated for each patient on the basis of the detailed 
information in the medical records. The AOFAS ankle-hindfoot score is 
a 100-point objective and subjective score that assesses pain, function, alignment, 
and joint motion. The scores are rated as excellent (90 to 100 points), good (80 
to 90 points), fair (70 to 80 points), or poor (<70 points). Preoperative 
anteroposterior and lateral weight-bearing radiographs were measured to 
quantify the anteroposterior talar-first metatarsal angle, the talar-first 
metatarsal angle, the talar-horizontal angle, and calcaneal pitch (see Ap-
pendix) (Fig. 1). Preoperative CT scans were reviewed to determine the type of 
coalition (bone or cartilage), the size of the coalition (the ratio of the surface 
area of coalition relative to the surface area of the posterior facet), and the thickness

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<td>1, L</td>
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<td>–13</td>
<td>30</td>
<td>13</td>
<td>65%</td>
<td>Narrow</td>
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<td>2, L</td>
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<td>PM midfoot</td>
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<td>–8</td>
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<td>–10</td>
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<td>–22</td>
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<td>–44</td>
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<td>–28</td>
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<td>6, R</td>
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<td>PM midfoot</td>
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<td>–12</td>
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<td>7</td>
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* CLO = calcaneal lengthening osteotomy, TAL = Achilles tendon lengthening, †AL = anterolateral, and PM = plantar-medial.

Materials and Methods

Approval for the study was obtained from our hospital’s institutional review board. Patients were selected for review if they had a middle facet talocalcaneal tarsal coalition and had had operative lengthening of the calcaneus between January 1991 and March 2005. Calcaneal lengthening osteotomy was performed in sixteen feet in eleven patients. Three distinct groups were identi-
Surgical Technique

If the coalition was being resected concurrently, that procedure was performed first with use of a standard longitudinal incision directly medial to the middle facet. Fat graft was obtained from the ipsilateral buttock skin crease area. Calcaneal lengthening surgery was performed by the senior author according to his published technique, which is based on the concept of Evans’.

The treatment of a rigid flatfoot with calcaneal lengthening osteotomy involves the use of the same principles and technique as the treatment of a flexible flatfoot, including peroneus brevis and abductor digiti minimi lengthening to allow distraction of the osteotomy site, preservation of the peroneus longus to act as a passive pronator of the supinated forefoot, pinning of the calcaneocuboid joint (before distraction of the osteotomy site) to prevent subluxation, and plantar-medial plication of the talonavicular joint capsule and tibialis posterior tendon. A few details specific to calcaneal lengthening osteotomy in a rigid flatfoot should be highlighted. First, the sinus tarsi is a size ratio of <50%, a wide (thick) posterior facet, and <16° of hindfoot valgus measured on the coronal CT image. We used the site or sites of pain and the amount of hindfoot deformity to support the decision for deformity correction, either with or without coalition resection.

All identified patients had more than two years of follow-up and were invited to return for clinical review. All of the patients who were located returned. Returning patients completed a questionnaire (see Appendix), underwent a physical examination, and had standing anteroposterior and lateral foot radiographs. Radiographic measurements were compared with the preoperative values.

A current AOFAS ankle-hindfoot score was established for comparison with the estimated preoperative score.
rigid flatfoot is obscured because of the fixed everted relationship between the talus and the calcaneus. This makes it difficult, although not impossible, to identify the interval between the anterior and middle facets, the termination of the medially directed calcaneal osteotomy. Second, the talocalcaneal tarsal coalition involves the middle facet, so the interval can be identified with the same success as in a flexible flatfoot with use of a Freer elevator with fluoroscopic guidance, if needed. Third, medially, a longitudinal utility incision is used to plicate the tibialis posterior tendon and the talonavicular joint. If the coalition is being resected concurrently, this incision is a distal extension of the one used for the resection. Fourth, it is extremely important to release the dorsolateral talonavicular joint capsule in these feet. Many feet with longstanding talocalcaneal tarsal coalitions develop dorsal osteophytic beaks on the talus and navicular. These osteophytes often create a fibro-osseous bridge that prevents the navicular from rotating from its everted dorsolateral position to the desired inverted plantar-medial position. An osteotome is sometimes required to resect or release the bridge. Fifth, in contrast to the flexible flatfoot, determination of the need for a gastrocnemius recession or an Achilles tendon lengthening in a rigid flatfoot can only be made after the calcaneus has been lengthened. This is because the Silfverskiöld test, which differentiates the two, requires inversion of the subtalar joint to neutral, which is an impossibility in a foot with a talocalcaneal tarsal coalition. Sixth, although only two of the sixteen feet required a plantar-based closing-wedge osteotomy of the medial cuneiform to correct rigid supination deformity of the forefoot, intraoperative assessment of the presence of this second deformity must be made and it must be corrected if identified. Seventh, postoperative immobilization is the same as that required for the calcaneal lengthening osteotomy, regardless of whether or not the coalition is concurrently resected. A short-leg non-weight-bearing cast is used for eight weeks, with a cast change and removal of the lateral column Steinmann pin at six weeks. Weight-bearing is commenced at eight weeks.

**Source of Funding**

A general departmental fund (the Staheli Endowed Chair Research Fund) was used to pay for long-term follow-up radiographs that were made at Seattle Children’s Hospital (rather than billing the subjects’ insurance carriers for these research images) and for automobile gasoline for some of the subjects to return to Seattle from long distances for long-term follow-up visits. This funding played no part in the study and did not influence the outcome.

**Results**

During the study period, eleven patients underwent sixteen calcaneal lengthening osteotomies. Of these, three patients with three calcaneal lengthening osteotomies (including one patient [one foot] from Group 1 and two patients [two feet] from Group 3) were excluded because they were unable to be contacted. Eight patients (thirteen calcaneal lengthening osteotomies) with more than two years of follow-up returned for evaluation.

**Group 1**

Group 1 consisted of five patients who underwent nine isolated calcaneal lengthening osteotomies because the coalitions were not resectable on the basis of the criteria of Wilde et al. The average coalition size was 89% (range, 65% to 105%) of the area of the posterior facet, with all coalitions being solidly ossified; the posterior facet was narrower than the ankle joint in all cases; and the average hindfoot valgus angle was 31° (range, 16° to 50°) (Table I).

Preoperatively, despite prolonged nonoperative management, most patients experienced daily activity-related pain under the plantar-medial aspect of the talar head. The others experienced activity-related impingement-type pain dorsolaterally in the sinus tarsi and/or ankle pain.

With these signs and symptoms and no evidence of arthritis in Chopart joints, it was apparent that the pain was due to the valgus deformity. All patients underwent a standard calcaneal lengthening osteotomy, as described in the Surgical Technique section. Simultaneous bilateral procedures were performed in...
one patient. Another patient had the procedure performed in the second foot a week later. In all other patients, bilateral procedures were staged with six months between operations. All underwent concurrent gastrocnemius recession (a Strayer procedure) or were staged with six months between operations. All underwent concurrent gastrocnemius recession (a Strayer procedure) or were staged with six months between operations. All underwent concurrent gastrocnemius recession (a Strayer procedure) or were staged with six months between operations. All underwent concurrent gastrocnemius recession (a Strayer procedure) or were staged with six months between operations. All underwent concurrent gastrocnemius recession (a Strayer procedure) or were staged with six months between operations. All underwent concurrent gastrocnemius recession (a Strayer procedure) or were staged with six months between operations. 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Figs. 3-A through 3-D Radiographs of the same foot shown in Figure 2. Figs. 3-A and 3-B Preoperative anteroposterior and lateral radiographs showing the unresectable talocalcaneal tarsal coalition shown on the CT scan in Figure 2. The dotted green line in Figure 3-A represents the calcaneocuboid joint. Figs. 3-C and 3-D Anteroposterior and lateral radiographs following calcaneal lengthening osteotomy and Achilles tendon lengthening without resection of the coalition. There was complete deformity correction in both planes.
Figs. 4-A, 4-B, and 4-C Case 7. **Fig. 4-A** Standing lateral radiograph of the foot of a ten-year-and-two-month-old girl, made immediately before resection of a talocalcaneal coalition. After the resection, the foot became flatter (as seen in **Fig. 4-B**) and pain recurred. **Fig. 4-B** Standing lateral radiograph made 2.5 years later, immediately before a calcaneal lengthening osteotomy. **Fig. 4-C** Standing lateral radiograph made after calcaneal lengthening osteotomy, showing correction of the deformity.
A calcaneal lengthening osteotomy and Achilles tendon lengthening were performed at the age of 12.6 years. Fifteen years and three months later, the patient had no pain and was satisfied with the results of the operation. The AOFAS ankle-hindfoot score improved from 69 to 100. All radiographic angles corrected to normal (Table I).

The second patient also had previously undergone resection of a middle facet talocalcaneal tarsal coalition, but the surgeon had failed to recognize a coincident calcaneonavicular coalition. When the patient presented with daily pain in the sinus tarsi region and the medial talonavicular joint, radiographs demonstrated talonavicular arthritis. Intraoperatively, severe talonavicular arthritis was confirmed, so a talonavicular joint arthrodesis was performed along with the calcaneal lengthening osteotomy at the age of 17.7 years. All radiographic angles corrected to normal (Table I). The patient reported initial reduction of pain that lasted for several years. However, at the time of latest follow-up, twelve years later, he reported daily pain that limited walking and running endurance. The patient was not satisfied with the long-term results of the operation. This is perhaps not unexpected, because his operation was actually a calcaneal lengthening modification of a double arthrodesis. The AOFAS ankle-hindfoot score improved from 74 to 84.

Discussion

There is general consensus that resection and interposition fat grafting is the treatment of choice for persistently painful middle facet talocalcaneal tarsal coalitions despite prolonged attempts at nonoperative treatment. However, coalitions that share certain characteristics have poor outcomes following resection. In 1994, Wilde et al. identified the characteristics that predict a poor outcome and recommended against resection in this group. Unfortunately, those authors did not definitively identify which of the three characteristics is most important or the order of importance. Although their clinical results confirmed the validity of the criteria for resectability, their recommendation of triple arthrodesis for coalitions that are not resectable was not supported or validated by their data. Other authors also have recommended triple arthrodesis for the treatment of unresectable coalitions as well as for feet that have recurrent or persistent pain after resection, but without principles-based justification or clinical outcome data to support their recommendations.

Triple arthrodesis leads to stress transfer to the ankle joint with the subsequent development of degenerative arthritis, a potentially disastrous outcome. Subtalar arthrodesis also has been shown to lead to stress transfer to the ankle joint and also to the Chopart joints. This sharing of stress at least theoretically provides some stress relief for the ankle joint. Therefore, unless there is clear evidence that the pain in a foot with an unresectable tarsal coalition is due to degenerative arthritis in the Chopart joints (which is rare in adolescents), it would seem desirable to attempt to relieve the deformity-associated pain by using the calcaneal lengthening osteotomy to correct the valgus hindfoot deformity while preserving motion in the Chopart joints. The calcaneal lengthening osteotomy appears to be a desirable alternative to triple arthrodesis for a painful foot with severe valgus hindfoot deformity and an unresectable, solid talocalcaneal tarsal coalition.

Several authors have reported good deformity correction and pain relief following calcaneal osteotomies in feet with symptomatic talocalcaneal tarsal coalitions. Dwyer believed that the pain in these feet was due to activity-related strain on the subtalar ligaments. He performed a posterior calcaneus lateral opening-wedge osteotomy to correct the valgus deformity in eleven painful rigid flatfeet. Although the results for this series were not published, the author reported in 1976 that the patients were progressing well and that the pain had been relieved.

Cain and Hyman reported on a series of fourteen spastic (rigid) flatfeet in eight patients in whom they performed medial closing-wedge osteotomy of the posterior part of the calcaneus without resection of the coalition. Four feet had isolated talocalcaneal tarsal coalitions, eight had isolated calcaneonavicular coalitions, and two had both talocalcaneal and calcaneonavicular coalitions. All patients had pain relief at between five and 11.5 years of follow-up. All patients developed a vertical heel, but ten had a persistent flatfoot.

Nine of the patients in the landmark study by Evans on the calcaneal lengthening osteotomy had rigid flatfeet. Evans did not clearly specify the pathoanatomy in these feet, although he stated that “The shape of the foot is slightly improved but the most gratifying features are the relief of pain and a subjective feeling of freedom within the foot.” Luhmann and Schoenecker performed calcaneal lengthening osteotomy for the treatment of persistent pain and the correction of deformity in the foot of a child who had previously undergone resection of a talocalcaneal tarsal coalition. Mosca reported deformity correction and relief of pain in one child who underwent calcaneal lengthening osteotomy for the treatment of an unresectable talocalcaneal tarsal coalition.

Those studies all suggested that the treatment of talocalcaneal tarsal coalitions should not be based solely on the size and resectability of the coalition; valgus deformity must also be considered.

It has been shown by multiple authors that calcaneal lengthening osteotomy reliably corrects all components of valgus/eversion deformity of the hindfoot at the site of deformity and relieves pain in patients with a flexible flatfoot and a short Achilles tendon. Although perhaps counterintuitive, calcaneal lengthening osteotomy in a rigid flatfoot with a middle facet tarsal coalition likewise reliably corrects all components of valgus/eversion deformity of the hindfoot. This clinical observation was previously reported by Evans and Mosca. An explanation for this finding is found in the 2005 study by Dumontier et al. Using three cadaveric feet and three-dimensional CT imaging, they showed that all of the corrective effects of the calcaneal lengthening osteotomy take place distal to the site of the osteotomy, which, according to Mosca, is performed between the anterior and middle facets. It is immaterial whether the middle facet is normal or coalesced.
The main limitation of our study is the small sample size. However, on the basis of a careful evaluation of the literature and our observations on the thirteen feet in this series, we believe that the alignment of the subtalar joint is as important as the size of the coalition and the health and mobility of the posterior facet. If the coalition is large and osseous and the posterior facet is narrow, it is not resectable. If there is excessive hindfoot valgus deformity, with or without a resectable coalition, correction of the valgus deformity is necessary for pain relief, whether or not the coalition is resected. It is, of course, important to ensure preoperatively that these radiographic features are correlated with the location or locations of the pain. An algorithmic approach to the treatment of talocalcaneal tarsal coalitions that is based on signs, symptoms, and imaging is proposed (Table II).

We believe that our data show that calcaneal lengthening osteotomy, with adherence to the published details of the procedure\(^{15,17}\), is a good alternative to triple arthrodesis for a painful foot with a talocalcaneal tarsal coalition and severe valgus hindfoot deformity. Reorientation of the Chopart joints allows them to continue to function as “pseudo-subtal joints” and thereby diminish the stresses transferred to the ankle joint. If the Chopart joints become degenerative and painful in the future, it will be technically easy to fuse those joints in situ. The time between operations can be considered time for stress relief for the ankle joint.

Appendix

Data supplement at jbjs.org.

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References