CURRENT OPERATIVE SURGERY

Orthopaedics and Trauma

Edited by

S. P. F. Hughes,

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Preface

This book contains a cross-section of new and interesting operative procedures described by authorities in the field. There are chapters on children's orthopaedics; the upper limb and neck; the lower limb; and the spine. There are also chapters on the use of external fixation and techniques on large joint replacement.

The book is aimed at practising orthopaedic surgeons who would like to know about new operative techniques and the results of treatment.

Each operation is described in detail and although every surgeon would not necessarily use all these procedures, he/she should gain an insight into the methods involved from surgeons who have either described the procedure or who use the technique in their practice.

The range of subjects is wide and the authors are from an international field.

Sean P. F. Hughes

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Clubfoot in Children

G. W. Simons

This chapter presents the complete subtalar release (CSTR), an extensive surgical procedure for correcting abnormalities of the hindfoot that resist conservative treatment. The CSTR has two advantages over other procedures: (1) a greater degree of correction, and (2) superior alignment of the foot and leg. After defining the procedure, explaining the underlying anatomical theory and comparing the results of the CSTR to less extensive procedures, this chapter will cover five main topics: (1) indications for the CSTR, (2) preoperative diagnostic procedures and treatment, (3) the required and optional or secondary operative procedures, (4) postoperative regimens, and (5) results and complications.

The CSTR consists of a standard posterior medial release with the addition of a lateral release of the talonavicular joint, the lateral subtalar joint, including the calcaneofibular ligament and the interosseus talocalcaneal ligament. Since 1971, when Turco published his paper on the posterior–medial release (PMR) that procedure has become the surgical treatment of choice for most clubfeet[1]. While the PMR has produced much better results than the procedures used in the past, such as Achilles tendon lengthening, in the experience of many surgeons, persistent or recurrent deformity often followed the PMR. McKay's 1977[2] paper provided the theoretical basis for development of the CSTR. McKay argues persuasively that in the untreated clubfoot the calcaneus is rotated beneath the talus around a vertical axis that passes through the centre of the subtalar joint[3]. In order to derotate the calcaneus, it follows that the entire joint must be free to twist. The CSTR permits the entire joint to rotate, allowing the surgeon to position the articular surfaces properly and to pin the bones in normal positions.

The PMR and posterior–medial and (antero) lateral release (PMLR)*, by contrast, produce a hinging effect at the lateral talocalcaneal joint, because one major group of ligaments is left intact, i.e. the lateral subtalar capsule and associated ligaments. These ligaments, which remain contracted, prevent complete correction at the time of surgery, or in the months and years following an EPR, a PMR or PMLR, and often gradually pull the foot back into a deformed position. While it would be possible to perform a PMR or PMLR and later perform additional lateral releases where necessary, once they have been performed the extensive scar tissue makes later soft tissue surgery extremely difficult, and satisfactory results are much less common. Since McKay's first paper, anatomical studies of teratological and typical stillborn clubfeet have demonstrated the validity of the concept of calcaneal rotation. These studies also showed that a lateral release was necessary for full correction of the abnormalities.[4,5]

A comparative clinical study has also conclusively demonstrated the superiority of the CSTR to PMLR and PMR.[6] Between September 1978 and August 1983, the author performed 127 clubfoot procedures. Of these, 51 were selected for comparison: 26 feet treated by PMR** and two closely re-

* PMLR (posterior medial and [anterior] lateral release) = PMR + complete talonavicular capsulotomy + anterior one-half lateral subtalar capsulotomy.

** PMR (posterior medial release) = EPR + anterior subtalar capsulotomy.

lated procedures (EPR† and PMLR) and 25 feet treated by CSTR. The remaining cases were excluded from the study for several reasons, including surgery completed less than 2 years before the comparison, patients not available for follow-up, patients who were successfully treated with minor procedures, and atypical clubfeet caused by neuromuscular diseases. Measurements of preoperative and postoperative radiographs showed that the CSTR produces more correction of AP-talocalcaneal divergence, AP navicular position, and the lateral tibial calcaneal angle. Statistical analysis confirmed that these differences were significant to the 0·01 or 0·05 levels. These three measurements are key indicators of correction of (respectively) hindfoot varus, talonavicular subluxation, and hindfoot equinus. The CSTR patients also required fewer subsequent surgeries and showed superior alignment of the foot with the knee and leg. It should be emphasized, however, that the CSTR is a more radical procedure than the posterior medial release, requiring a thorough and detailed knowledge of the anatomy and pathology of the clubfoot. A complete subtalar release probably should not be attempted by surgeons who rarely perform clubfoot surgery.

INDICATIONS FOR CSTR

Four criteria should be used to decide whether a complete subtalar release is indicated. First, CSTR should be used for varus or talonavicular subluxation, not for equinus alone. Second, the child's foot should be at least 8 or 9 cm long; size is a more important criterion than chronological age. Third, the child should probably be under 4 years old for the best results. Our highest rate of satisfactory results occurred in patients under a year old;[6] after that, the rate of success began to drop off slowly. After 4 years of age, the advanced stage of bone and structural deformity reduces the probability of success. An exception to this criterion is the use of CSTR as a method for properly aligning the foot and leg. In such a case, the significant improvement in gross function and appearance is worth the possibility of some loss in range of motion. The fourth criterion, then, is for correction of medial rotation of the foot with respect to the leg and knee. In addition to these indications, there are several conditions, such as flat top talus and marked restriction of ankle motion, that the surgeon should keep in mind when deciding whether to perform the CSTR; these conditions are not contraindications, but they reduce the likelihood of a fully successful result. The next section discusses preoperative diagnosis and treatment of complicating factors.

† EPR (extended posterior release) = posterior release + medial subtalar capsulotomy + medial talonavicular capsulotomy.

PREOPERATIVE EXAMINATION AND CARE

Preoperative care before the CSTR includes two types of procedures: diagnostic procedures for identifying underlying complications, and therapeutic procedures for increasing the range of motion and reducing rocker bottom foot.

If the patient's total range of ankle motion is less than 30° (determined by lateral dorsiflexion and plantarflexion views and measurement of the lateral tibial talar angles), the parents should use stretching exercises—especially in plantarflexion—for at least 2 weeks before surgery. If plantarflexion is still restricted, an ankle arthrogram should be done to determine whether this is due to flat top talus or anterior ankle contracture. Flat top talus is difficult to diagnose in very young feet without arthrography because the talar ossification centre is immature. At this time there is no known treatment for flat top talus; since it is caused by prolonged and forceful casting, it follows that early surgery is indicated for treatment of the recalcitrant foot, for once the talus is flattened, motion is permanently limited. Anterior ankle contracture is caused by prolonged immobilization in dorsiflexion with consequent limitation of plantarflexion. Anterior ankle contracture can be treated by stretching exercises in the very young child or an anterior ankle capsulotomy which should be performed *before* CSTR so that there is enough talar mobility to allow the talus and calcaneus to be properly aligned during the CSTR.

Flat feet and rocker bottom feet are also often caused by conservative treatment. In the comparative study, flat feet were defined as those having a lateral calcaneal first metatarsal angle between 170° and 180°. Rocker bottom feet were defined as having lateral calcaneal first metatarsal angles greater than 180°.

Both flat feet and rocker bottom feet can be successfully treated with casting in very young children by reversing the corrective forces and holding the foot in plaster for 4–6 weeks before surgery. If not corrected preoperatively, these residual deformities are usually not successfully treated by surgery.

The postoperative range of ankle motion is cur-

rently a primary concern in the further development of the CSTR. Two factors tend to reduce the range: prolonged conservative casting before surgery and prolonged cast immobilization after surgery. Four factors seem to increase the range of ankle motion: (1) stretching exercise before surgery, (2) exercise beginning a few days after surgery with a hinged cast, (3) a shorter period of casting and pin-retention after surgery, and (4) ligamentous laxity. In our study, there was a high statistical correlation between ligamentous laxity and good range of motion.

The presence of flat top talus, rocker bottom, or restricted ankle motion may limit the probability of a satisfactory result. If the latter two conditions are accurately diagnosed and treated before CSTR, however, the results will be more satisfactory.

SURGICAL DETAILS

Two approaches to the CSTR are possible, one with a single incision, the other using two incisions. The double-incision technique uses a standard posterior medial incision and a separate lateral incision. In some respects, this approach is simpler to use, but it is extremely difficult to locate and visualize the lateral talonavicular joint surface with this method. We now use the single incision approach almost exclusively in children under 3 years of age. This method requires a single U-shaped incision, parallel to the plantar surface of the foot, that extends from the medial side around the heel to the lateral side. Crawford[7] attributes this 'Cincinnati' approach to Giannestras. The full procedure will be described in three sections: details of the incision, of the preliminary dissection, and of the capsulotomies and ligament releases. Radiographic techniques are described next, followed by a discussion of secondary surgical procedures, talar blood supply and pinning procedures.

The Cincinnati incision

To begin the Cincinnati incision, the patient is placed in the *prone* position. The torniquet is wrapped as tightly as possible, as any leakage will make dissection difficult. The leg is elevated for partial exsanguination; there should be enough blood in the vessels to allow them to be identified during dissection. The knee is draped free and the patella and tibial apophysis are marked with indelible ink so that later the foot and knee can be more easily aligned. The incision is started at the level of the first metatarsal cuneiform joint and is carried around the heel at or just above the level of the skin crease. Then the incision is extended forward to the level of the lateral talonavicular joint. The incision should curve upwards slightly at its anterior lateral aspect.

The skin and subcutaneous tissue are dissected proximally over the Achilles tendon and on either side of the tendon. The sural nerve is identified by blunt dissection and the nerve is freed of soft tissue for 2–3 cm proximally and distally.

The medial side of the foot is dissected next. The abductor hallucis is dissected from its origin on the fascia overlying the first metatarsal and the laciniate ligament; then the muscle is retracted toward the plantar surface. As the abductor hallucis is reflected off its underlying fascia, the medial plantar nerve can often be seen beneath its fascia, extending to the distal end of the incision. The fascia overlying the medial plantar nerve need not be incised.

A small incision is made over the nerve in the sheath of the neurovascular bundle, just above the malleolus. A scored Frazier dural elevator is inserted into the sheath, which is then opened by cutting down onto the elevator. This release is carried proximally as far as the skin incision will permit and distally to the point where the plantar nerves and vessels bifurcate. By this means, the laciniate ligament is divided and the neurovascular bundle is freed from its sheath, so that it can be retracted later.

If a *plantar release* is indicated, it can be performed at this time, or it can be left until a later stage of the procedure when the bones have been positioned in normal relationships. If the foot is severely deformed, the plantar release should generally be done at this stage (Figure 1.1).

Next, the Achilles tendon is dissected posteriorly and on its medial and lateral sides so that—depending on the patient's age—6–8 cm of the Achilles can be lengthened sagittally or coronally during the Z-lengthening. As much length as possible should be gained. If the Achilles is lengthened sagittally, the lateral half of the distal arm should be left attached to the calcaneus to produce a valgus force on the heel when the tendon is repaired.

The flexor digitorum communis sheath is incised above the ankle. A Frazier dissector is used to help incise the sheath. The tendon sheath is opened to Henry's knot and the knot is released. Then the posterior tibial tendon is lengthened above the ankle as far proximally as possible but not distal to the malleolus. Finally, the flexor hallucis longus is exposed above the ankle to its canal beneath the talus so that it can be retracted later.

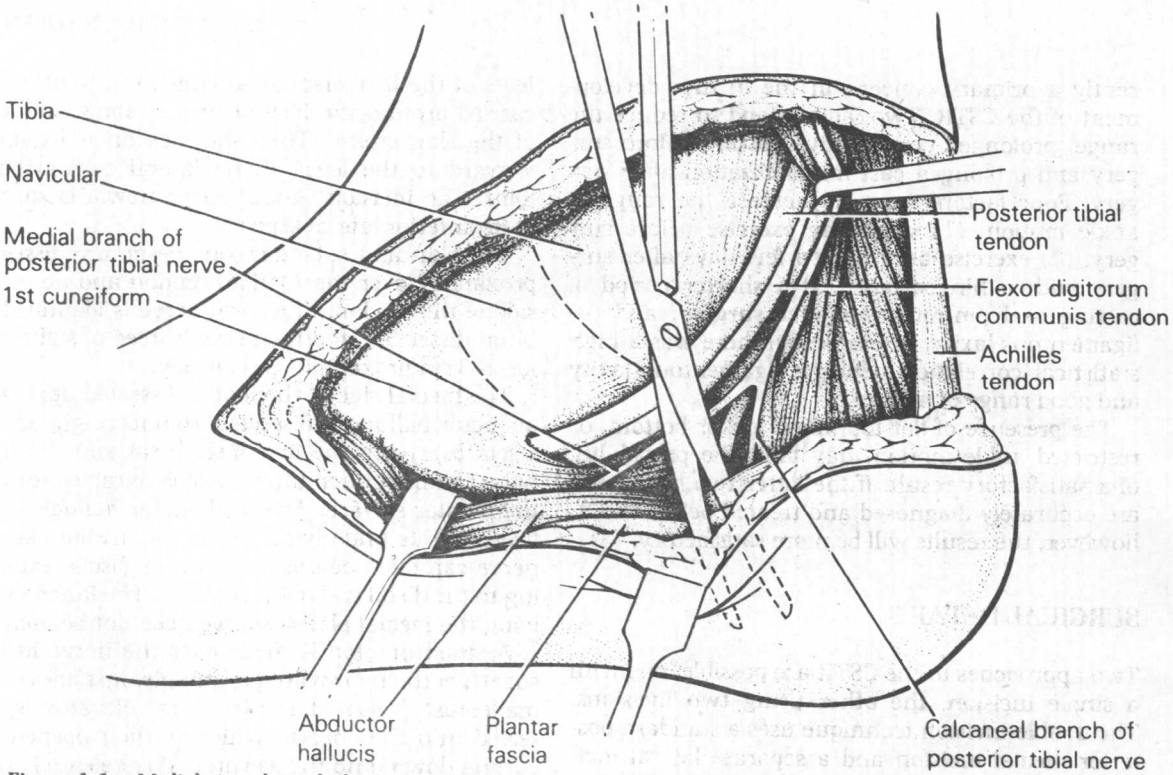

Figure 1.1 *Medial view through the Cincinnati incision depicting plantar release. The origin of the abductor hallucis is released proximally along with the medial half of the plantar fascia and quadratus planti. The upper blade of the scissors is inserted in the axilla between the calcaneal nerve and lateral plantar nerve and artery. The lower blade of the scissors is inserted between the plantar fascia and skin. The scissors must be kept on the anterior surface of the calcaneus to avoid cutting the plantar nerve and vessels.*

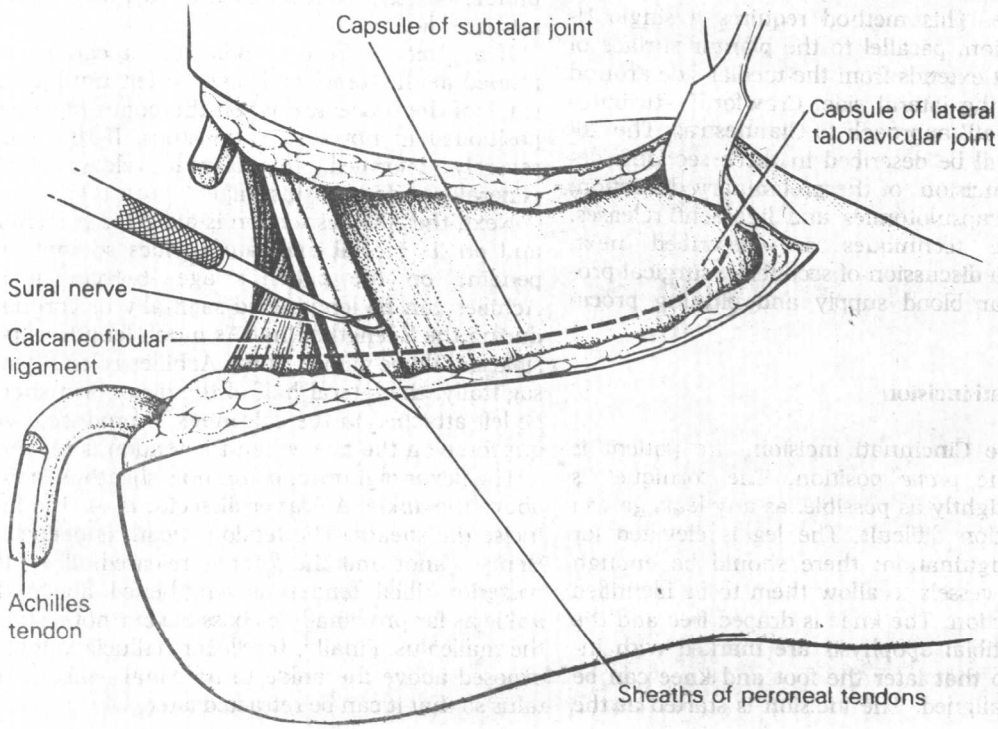

Figure 1.2 *Lateral view of the foot through the Cincinnati incision depicting the level of the incision in the peroneal tendon sheaths, the calcaneofibular ligament, the subtalar joint capsule and the lateral talonavicular joint capsule.*

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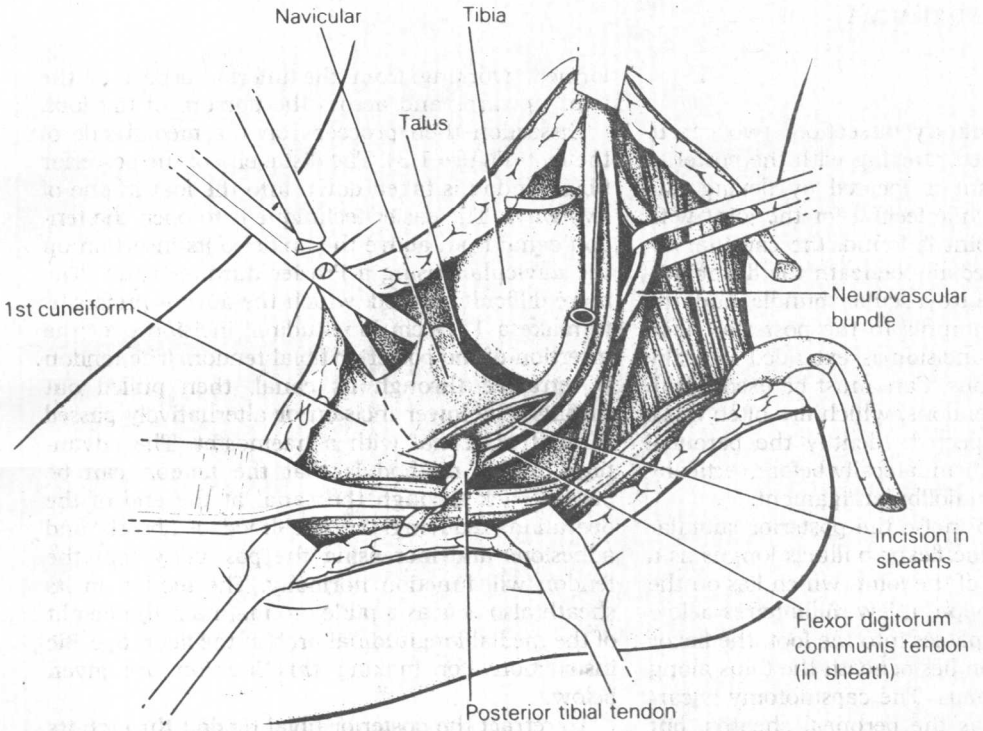

Figure 1.3 *Medial view through Cincinnati incision depicting the technique of lengthening the posterior tibial tendon and passing it down through its intact sheath into the foot. The sheath is incised at the level of the tibionavicular articulation. Note that the talar head lies deep to the navicular and cannot be seen in this drawing.*

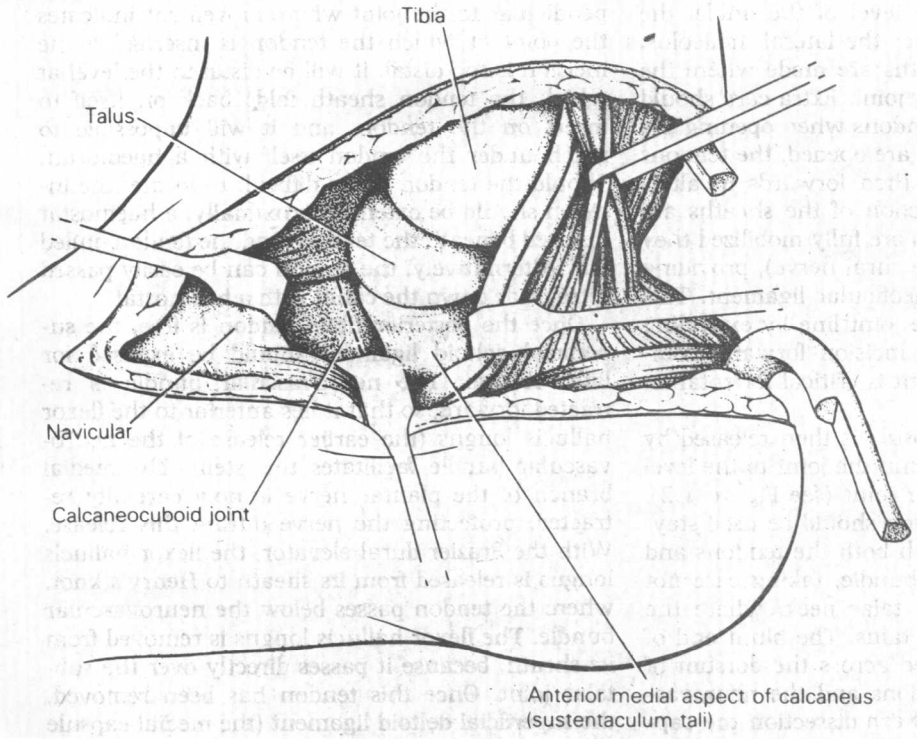

Figure 1.4 *Medial view of the foot through the Cincinnati incision depicting the location of the medial aspect of the calcaneocuboid joint deep within the medial wound. It is located by probing the depth of the wound with a Keith needle or scalpel blade just distal to the lateral projection of the calcaneus. This joint is released alternatively through the medial and lateral wounds on its dorsal medial and volar surfaces. The lateral capsule is left intact.*

Capsulotomies

Following the preliminary dissection, two capsulotomies are performed, starting with the posterior ankle joint. This joint is located by flexing and extending the foot while feeling for the joint with forceps. When the joint is found, the capsular incision is extended medially beneath the flexor hallucis longus, the neurovascular bundle and the flexor digitorum communis to the posterior tibial tendon sheath. The incision is extended laterally to the peroneal tendons. Care must be used not to incise the peroneal tendons, which are often more posterior than is expected. Identify the peroneal tendons and retract them laterally before vertically incising the posterior talofibular ligament.

The next step is to incise the posterior subtalar joint capsule, using the flexor hallucis longus as a guide to the location of the joint, which lies on the lateral side of the tendon, a few millimetres below the ankle joint. As it passes into the foot, the flexor hallucis longus tendon lies beneath the talus along the side of the calcaneus. The capsulotomy is carried laterally as far as the peroneal sheaths, but these sheaths should not be opened at this level.

The peroneal sheath incisions should be made over the lateral rather than the posterior subtalar joint (Figure 1.2). If these incisions are made over the posterior joint at the level of the ankle, the tendons can subluxate over the lateral malleolus. The incisions in the sheaths are made where the tendons cross the subtalar joint. Extra care should be taken not to cut the tendons when opening the sheaths. Once the sheaths are opened, the tendons are retracted backwards, then forwards in alternation while the deep section of the sheaths are incised. When the tendons are fully mobilized they can be retracted (with the sural nerve), providing access to the large calcaneofibular ligament. This ligament is released at the joint line by extending the posterior subcapsular incision forward; complete release of the ligament is critical for rotation of the calcaneus.

The lateral subtalar capsule is then released by cutting outwards from within the joint to the level of the lateral talonavicular joint (see Figure 1.2). At this level, blunt dissection should be used staying on the capsule, beneath both the tendons and the dorsal neurovascular bundle, taking care not to dissect dorsally on the talar neck, where the leash of vessels enters the talus. The blunt end of a Senn retractor is inserted across the dorsum of the foot, beneath the tendons and the neurovascular bundle. Then with sharp dissection the capsulotomy of the lateral talonavicular joint is performed, working from the inferior aspect of the joint upwards and across the dorsum of the foot.

Dissection then proceeds on the medial side of the foot (Figure 1.3). The distal end of the posterior tibial tendon is taken down into the foot in one of two ways. The easier technique is to open the tendon canal from above the ankle to its insertion on the navicular, using a Frazier dural elevator. The more difficult method, which the author prefers, is to make a 1–1½ cm longitudinal incision over the insertion of the posterior tibial tendon. The tendon is retracted through its canal, then pulled out through the lower incision or alternatively passed through its canal with a haemostat. The advantage of this method is that the tendon can be passed back through the canal at the end of the operation, reducing the likelihood of fibrosis and adhesions and increasing the possibility that the tendon will function normally. The tendon in its sheath also acts as a pulley to maintain the height of the medial longitudinal arch of the floor. Specific instructions for making this incision are given below.

To retract the posterior tibial tendon through its sheath, the articulation is palpated between the navicular and the anterior inferior tibial malleolus while pulling gently on the distal end of the tendon (see Figure 1.3). The incision should be made perpendicular to the joint where movement indicates the point at which the tendon is inserted. If the incision is too distal, it will be distal to the level at which the tendon sheath folds back on itself to insert on the tendon, and it will impossible to reach under the tendon itself with a haemostat. Should the tendon prove difficult to locate, the incision should be extended proximally, a haemostat inserted beneath the tendon, and the tendon pulled out. Alternatively, the tendon can be easily passed retrograde down the canal with a haemostat.

Once the posterior tibial tendon is free, the superficial deltoid ligament should be exposed for later release. The neurovascular bundle is retracted forward, so that it lies anterior to the flexor hallucis longus (the earlier release of the neurovascular bundle facilitates this step). The medial branch of the plantar nerve is now carefully retracted, protecting the nerve during this release. With the Frazier dural elevator, the flexor hallucis longus is released from its sheath to Henry's knot, where the tendon passes below the neurovascular bundle. The flexor hallucis longus is removed from its sheath, because it passes directly over the subtalar joint. Once this tendon has been removed, the superficial deltoid ligament (the medial capsule of the subtalar joint) can be opened from the pos-

terior to the anterior aspect, using a scalpel with a Beaver blade and cutting outwards from within the joint. At the anterior end of the joint, the joint line can be hard to identify, with the result that the anterior medial aspect of the calcaneus can be easily amputated. If the anatomy is difficult to identify clearly, it is probably safer to leave this release unfinished until the talonavicular joint is open.

When the distal part of the posterior tibial tendon has been retracted, it can be used to locate the talonavicular joint. The naviculocuneiform joint lies distal to the proximal inserting fibres of the posterior tibial tendon; the talonavicular joint is proximal. The capsule of the tibionavicular articulation is incised dorsally and volarwards for a few millimetres. At this point, the talonavicular joint must be located; it will be easy or hard to find depending on the extent to which the navicular is subluxated. If the medial side of the talar head is convex, the talonavicular joint will also be convex. Alternatively, the joint surfaces might be flattened. A common error is to cut directly into the medial aspect of the talar neck, creating a false joint. To locate the joint, medial traction to the posterior tibial tendon stump should be applied to distract the joint medially.

With severe talonavicular subluxation, the head and neck of the talus will be deep within the tibionavicular articulation, and the navicular will be on the medial side of the talar head and neck. Under these circumstances, the talonavicular joint lies parallel to the long axis of the foot, making dissection and repositioning extremely difficult. The navicular must be placed on the distal end of the talus. A primary limitation of the PMR is that it often does not allow the surgeon to perform a complete release of the navicular. The best method for releasing the navicular is as follows:

1. Dissect bluntly across the dorsal capsule, staying beneath the tendons and neurovascular bundle, and staying distally on the dorsum of the talar head to avoid the dorsal blood supply to the talus.
2. Retract the posterior tibial tendon and open the tibionavicular articulation as far as possible.
3. Use a Beaver blade scalpel for the rest of the dissection.
4. Release the volar capsule (the spring ligament complex) and the dorsal capsule as far laterally as it is possible to visualize the capsule. Try to join the dorsal incision with the incision on the lateral side.
5. If the lateral capsular incision cannot be reached, return to the lateral wound and free the rest of the lateral talonavicular joint. Next the interosseus talocalcaneal ligament is released completely.
6. Return to the medial side of the foot and release the anterior medial aspect of the subtalar joint, if that has not already been released. The anterior medial aspect of the calcaneus projects upwards; be careful not to amputate it. In some feet, this area also forms a coalition with the talus; if such a coalition is present, it too must be released. When there is no coalition, the best approach for releasing the ligament is to cut posteriorly to anteriorly, moving outwards from within the joint. Then carry the release across the small *anterior* portion of the subtalar joint.
7. Cut the remaining dorsal and volar capsule of the talonavicular joint. Often, a single dorsal remnant of the capsule will be missed, and this remnant is enough to prevent free movement of the navicular. When the navicular is completely free, the movement of the midfoot around the talus will be easy. Anything less than free movement must not be accepted. Pass a haemostat around the head and the distal end of the talus to be sure that no capsular strands remain. The navicular can then be repositioned on the distal end of the talus. This completes the CSTR unless a plantar release, calcaneal cuboid release, or wedge osteotomy are indicated. These procedures are described in the next section.

Secondary surgical procedure

If a plantar release has not been performed earlier, it can be done after the subtalar release. This is also the appropriate time for release of the calcaneocuboid joint or for anterolateral calcaneal cuboid wedge resection. The calcaneal cuboid release is used for patients under 3 years of age; vertical wedge resection of the calcaneus is used for patients over 3 years. The author prefers the latter method to the Evans and Lichtblau wedge resections because the calcaneocuboid joint is left intact. The wedge resection does not damage the middle or posterior facet joints.

Plantar release

The plantar release proceeds as follows (see Figure 1.1). The axilla between the calcaneal nerve and the lateral plantar nerve and artery is dissected bluntly. The edge of the plantar fascia in the plantar soft tissue is identified and the plantar surface of the fascia is freed of its adipose tissue. Metzenbaum or Mayo scissors are placed over the plantar

fascia so that one blade is on the plantar side and the other blade on the opposite side, but lying within the axilla of the calcaneal and lateral plantar nerves. The inner blade of the scissors should be kept against the anterior calcaneus so that the lateral plantar nerve and vessel are not damaged. Simultaneously, the quadratus plantae and the origin (superficial and deep heads) of the abductor hallucis are cut.

Calcaneocuboid release

A calcaneal cuboid release or wedge resection is indicated only if there is significant longitudinal malalignment of the midfoot and the forefoot following the CSTR (that is, residual metatarsus adductus) (Figure 1.4). The calcaneocuboid release is a technically difficult procedure. The surgeon should begin with the medial wound, inserting three Senn retractors into the space among the anterior end of the medial calcaneus, the plantar structures, and the proximal edge of the navicular. Adipose tissue lies within the depth of this space and obscures the joint unless it is excised. The calcaneocuboid joint lies deep in the wound and can be found most effectively by probing with the tip of the scalpel or surgical needle distal to the medial aspect of the calcaneus, incising the medial side of the joint first. It is important to avoid cutting the peroneus longus tendon, which runs beneath the inferior aspect of the joint.

After incising of the medial aspect of the calcaneocuboid joint the lateral side of the foot is dealt with next. Since the interosseus talocalcaneal ligament has been released, the foot is easily displaced laterally beneath the talus and the dorsum of the calcaneocuboid joint is cut from above. The lateral calcaneus cuboid ligament should not be opened, because it serves as a hinge that stabilizes the midfoot on the hindfoot and prevents lateral and dorsal subluxation of the midfoot. When the dorsal aspect of the joint is open, the plantar aspect is released through the medial incision. If the peroneus longus is retracted plantarward, this release can now be performed without danger to the tendon.

Anterolateral calcaneocuboid wedge resection

The anterolateral calcaneocuboid wedge resection requires that a 0·5–1 cm lateral wedge be removed from the calcaneus. This osteotomy is made vertically, about 1 cm posterior to the calcaneal cuboid joint. Once the wedge is removed, the osteotomy is closed and fixed in place with one or two threaded Kirschner wires.

Limiting dangers to the blood supply

While the author has experienced no cases of talar avascular necrosis using CSTR during a period of almost 4 years, the CSTR is a major procedure that can imperil the blood supply to the talus. To avoid major vessels and damage to articular cartilage, dissection should always proceed outward from within the joint. When the lateral talonavicular joint is opened, it should be approched from its inferior lateral aspect. This way, the talonavicular joint can be found more easily, and the surgeon can avoid the leash of vessels that enters the dorsal neck of the talus. Dissection across the dorsum of the foot must be performed at the level of the talonavicular joint and not proximal to this level. Locating this joint both medially and laterally and keeping dissection at this level is important. The single U-shaped incision (Cincinnati approach) provides much easier access to the lateral talonavicular joint and probably reduces the likelihood of damage to the talar blood supply. The double incision approach, however, is preferable in the older foot, where skin necrosis is more likely.

When all primary and secondary procedures are complete, the foot can be pinned in a normal position. This is the most critical phase of the procedure; improper pinning can lead to undercorrection or overcorrection. It is important to follow pinning and x-ray protocols exactly.

Placement of Kirschner wires

Once the full CSTR is complete, the foot is free to move around the talus in any direction. For this reason, it must be pinned to the talus until the ligaments heal, and threaded Kirschner wires used to prevent pin migration. The wires are cut off neneath the skin after being inserted with power equipment; a wire size appropriate to the size of the foot is selected. Two to four pins are inserted, depending on the extent of the surgery and the types of secondary surgeries that are required. After the pins are inserted, radiographs are taken and measured to evaluate whether the foot has been properly repositioned. The normal radiographic range of measurements can be found in Table 1.1. Pins are removed and replaced until correct angular measurements are confirmed on the radiographs. Normally, this process requires only minor adjustments after the first pin is inserted. Details of the pinning procedures are described below. I cannot overemphasize the importance of placing the talonavicular and

talocalcaneal pins correctly and confirming the placement radiographically.

The talonavicular pin

The talonavicular pin is the most important, because it holds the talonavicular joint in place and generally establishes the new position of the talocalcaneal joint. The talar head may be quite deformed, and the navicular may appear to have two facets. The additional, medial facet will be located where the navicular has articulated with the tibia. While the surgeon exposes the talonavicular joint, one assistant must retract the neurovascular bundle and the other assistant insert the Kirschner wire through the lateral aspect of the posterior ridge of the talus. The surgeon should instruct the assistant in guiding the pin so that it emerges at the most distal tip of the talar head.

Before inserting the pin across this joint, the knee is flexed and the proper relationship between the knee and the foot determined. The navicular is positioned on the distal end of the talus and the navicular must be neither too superior nor inferior, too lateral nor medial. The entire navicular–cuboid–calcaneal complex must be rotated (pronated) and shifted laterally. If the navicular is pushed laterally too far, however, the lateral articular surface of the navicular will subluxate. It is also critical to distinguish the true articular surface of the navicular from the articular facet that may have developed on the medial aspect of the navicular as a result of pressure on the navicular from the distal tip of the tibia. The navicular should be inspected for evidence of a second facet. The lateral aspect of the talonavicular joint is carefully palpated before and after the pin is inserted. Excessive lateral placement will cause a palpable lateral step at the joint. Ideally, the medial aspect of the navicular should protrude slightly on the medial side, and there should be no lateral protrusion on the lateral aspect of the joint. Also, the dorsal surfaces of the navicular and talus must be palpated to make certain there is no upward displacement of the navicular.

If the navicular is displaced laterally before the pin is drilled across the joint, it is possible to see where the pin emerges through the talar head. Then the navicular is properly positioned and the pin inserted across the talonavicular joint, but the pin should not be allowed to distract the joint as it enters, and it should exit on the dorsum of the foot. After the pin has been inserted, the foot is examined carefully while moving it through the full range of plantarflexion and dorsiflexion. The foot should not be in valgus or supinated and it should be externally rotated so that the foot and knee are properly aligned. If necessary, the pin is reinserted until the position of the foot and the range and direction of motion appear to be satisfactory. This pin placement is checked more accurately when radiographs are taken after all pins have been inserted.

The calcaneotalar pin

The calcaneotalar pin is inserted through the plantar surface of the heel into the calcaneus, across the subtalar joint, and into the body of the talus. It should not be placed across the ankle joint. The joint should be allowed to close as much as possible—without forcing the joint—and the pin inserted with the bones in this closed position. The rotation of the calcaneus should be checked against the foot–knee alignment.

The calcaneocuboid pin

One or two pins are used when an anterolateral calcaneal osteotomy has been performed. When inserting these pins, instruct an assistant to apply three point manual pressure on the foot: (1) over the medial heel, (2) over the lateral calcaneal osteotomy site, and (3) medially over the first metatarsal head. Then the first pin is inserted through the posterior calcaneus several millimetres below the skin incision and the pin directed towards the centre of the cuboid. It is easy to insert the pin too inferiorly. Ideally, the pin should strike the fourth or fifth metatarsal, but this rarely happens. When two pins are used, the second is inserted into the cuboid on the lateral side of the foot and it crosses the joint and osteotomy site into the calcaneus.

Postoperative radiographs, pin adjustment, and tendon lengthening

When the pins are in place, all pins are cut off with 1 cm protruding so that the pins can be repositioned if necessary after radiographs are taken. The tourniquet is removed and all bleeders are cauterized.

Anteroposterior and lateral radiographs should always be obtained. With the patient in the prone position, it is difficult to take a good anteroposterior radiograph. An acceptable view can be obtained by flexing the knee fully, plantarflexing the foot, placing the cassette over the plantar sur-

face, and positioning the x-ray tube just below the end of the table with the beam directed obliquely upward. The lateral view is easy to obtain with the patient prone. The anteroposterior and lateral talocalcaneal angles should be carefully measured (see Table 1.1 and Figures 1.5 to 1.8). On the anteroposterior view, the talar axis should bisect the base of the first metatarsal (see Figure 1.2). On the lateral view, the talar axis should pass through the base of the first metatarsal and superior to the ossification centres of the cuneiforms (Figure 1.8). These indications reveal whether the navicular is generally well-aligned with the talus. If the first metatarsal is not visible on the lateral view, the

Table 1.1 Normal angular measurements in children under 5 years of age.

A. On the anteroposterior radiograph:

a = Talocalcaneal angle (20°–40°)
b = Talocalcaneal divergence (0 to + 1)
c = Calcaneal second metatarsal angle (15°–20°)
d = Navicular position (Central)
e = TMT angle (15°)

B. On the lateral radiograph:

f = Talocalcaneal angle (35°–50°)
g = Calcaneal first metatarsal angle (140°–180°)
h = Tibial talar angle (Dorsiflexion = 70°–100°; plantarflexion = 120°–180°)
i = Tibiocalcaneal angle (Dorsiflexion = 25°–50°)

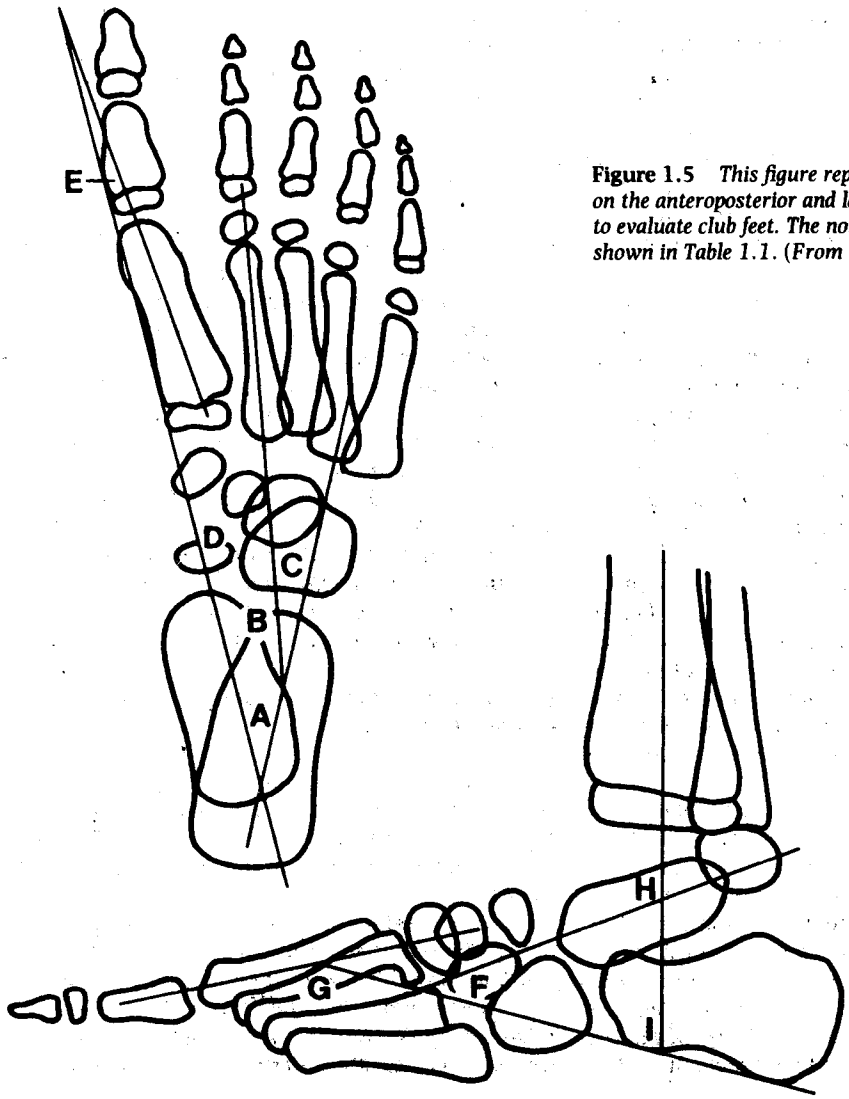

Figure 1.5 *This figure represents the radiographic angles on the anteroposterior and lateral views which may be used to evaluate club feet. The normal values for these angles are shown in Table 1.1. (From ref. 6.)*

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