Cavovarus deformity is defined by fixed equinus of the forefoot on the hindfoot, resulting in a pathologic elevation of the longitudinal arch, with either a fixed or flexible varus hindfoot deformity. The cause is most commonly associated with underlying neurologic disorders, with Charcot-Marie-Tooth disease. Other neurologic disorders include progressive disorders or lesions, such as myelodysplasia, spinal dysraphism, and syringomyelia. As it has been stated previously in the literature, cavovarus deformity manifests in the growing child with a consequent change in shape and position of bones. The muscle involvement progresses from distal to proximal, affecting primarily the tibialis anterior and peroneus brevis, with secondary dysfunction of the intrinsic muscles sparing of extensor hallucis longus is observed. This imbalance generates a varus hindfoot as the posterior tibialis remains unopposed by the peroneus brevis, creating a varus moment. The relative weakness of the anterior tibialis relative to the peroneus longus results in plantar flexion of the first metatarsal, which results in midfoot supination, and contributes to a forefoot-driven hindfoot varus. Secondary to weakness of the anterior tibialis muscle, recruitment of extensor hallucis longus occurs, resulting in a cock-up deformity of the great toe, with further depression of the metatarsal head and plantar contracture.

As a general principle, the imbalance must be corrected by canceling the deforming forces and improving the deficit; this is when tendon transfers become necessary. It has been reported that in cases when tendon transfers were not performed, the recurrence rate was higher. Performing arthrodesis in the foot does not preclude the need of adding tendon transfers because a correctly performed fusion may deform over time from an imbalance in the remaining motion segments and result in the recurrence of the deformity.

The general principles for tendon transfers are well known. It was Mayer who described many of the principles of tendon transfers still in use today. Although these principles are still valid, some additional details have been incorporated over time. Stable attachment of the tendon to bone is requisite for the long-term proper functioning of a tendon transfer. Different techniques have been described, including pull out using a button to fix the tendon, weaving the tendon through the bone, anchors, and the newer and most commonly used interference screw techniques. Tension: should correspond to half of the tendon excursion; although if there is any doubt, the authors prefer to leave it with a little bit more tension.

These ideal criteria are not always fully present; however, that should not impede us from performing the tendon transfer because we will eliminate a deforming force and support a deficient tendon action.

Tendon transfers should be performed after fixed deformities are corrected to achieve the appropriate tension of the tendon transferred. Some controversy remains as to whether performing tendon transfers and osteotomies early avoids triple arthrodesis in the future. As a general rule, the authors prefer to indicate surgery as soon as patients begin with symptoms unresponsive to medical treatment. Good results can be expected after correction of cavovarus deformity at the long-term follow-up after static and dynamic deformities are corrected.
TREATMENT STRATEGY
The authors plan their surgical decisions based on the level of deformity, which musculotendinous unit represent the deforming forces, and which need supplementation.
The authors propose the surgical strategy in figura 1 after the static deformities have been addressed. Incisions must be planned carefully, especially when several incisions and osteotomies are performed at the same time.

![Diagram of Treatment Strategy](image)

Fig. 1. Treatment strategy for tendon transfers in cavovarus. The diagram
presents the problem to treat or consider in white boxes and the surgical procedure in gray boxes.
Different options are included relative to the hindfoot first and then the midfoot. AT, anterior tibialis tendon; EDL, extensor digitorum longus; EH, extensor hallucis longus; PB, peroneus brevis tendon; PL, peroneus longus tendon; PT, posterior tibial tendon; TN, talonavicular joint.

SPECIFIC TENDON TRANSFERS:
PERONEUS LONGUS TO BREVIS TRANSFER
The most commonly performed tendon transfer is the peroneus longus to brevis to decrease the plantar flexion force of the peroneus longus and to increase the eversion power of the brevis to correct flexible varus. The maximal advantage is achieved in younger patients. In the authors’ protocol of treatment, it is the most common transfer performed; generally, it is indicated for ankle varus and/or ankle instability. The surgical options include using the same incision for the osteotomy of the calcaneus or through an incision close to the peroneus brevis incision at the base of the fifth metatarsal.

The authors prefer the retromalleolar approach because it is the easiest and safest in their hands. After cutting the peroneus longus and pulling it distally as far as possible, the authors release the tension slightly and suture it side by side to the peroneus brevis, holding the ankle in neutral flexion and eversion. The authors prefer to use a nonabsorbable suture, with at least 8 connection points between each tendon, preferably with a running-locked suture, which can withstand forces well beyond physiologic loads.

POSTERIOR TIBIAL TENDON TRANSFER TO THE CUNEIFORMS
Following the authors’ surgical strategy, the tendency to invert and the dorsiflexion power are evaluated. Most of the authors’ patients present with a weak anterior tibialis tendon. The peroneus longus to brevis tendon will help stabilize the ankle but will not be enough to stabilize the hindfoot. Therefore, the second most common tendon transfer that the authors perform is tibialis posterior to one of the cuneiform bones.

This transfer eliminates the principal deforming force of the hindfoot, which is the posterior tibialis, and reinforces the weak anterior tibialis. The chosen cuneiform depends on where the deformity is best corrected, and there is no general rule for all cases. This transfer is particularly necessary in Charcot-Marie-Tooth disease. It must be remembered that even a weak posterior tibial tendon should be transferred because the deforming force is canceled and at least a tenodesis effect will be obtained to aid dorsiflexion. In order to obtain optimal function from the transfer, the contracted posterior soft tissues must be released or lengthened. Most of the time, the posterior tibial tendon is just long enough to be transferred to the cuneiforms; therefore, a careful surgical technique must be used to obtain as much tendon as possible. If the tendon length is inadequate, a turndown flap can be performed or a formal graft can be used (the latter is rarely necessary).

The author’s preferred technique is to perform the transfer through the interosseous membrane, harvesting the tendon as distal as possible from a medial incision over the navicular bone. It is then passed proximally to an incision placed
medially over the leg, 15 cm above the ankle joint. A third incision is performed over the anterior tibia, 12 cm above the ankle joint line; the tendon is retrieved through the interosseous membrane, taking care in opening a wide window in the interosseous membrane with the help of long scissors or right-angle clamps. From this point, the tendon is passed subcutaneously to the dorsum of the foot where a fourth incision is placed over the cuneiforms.

Considering the length of the harvested tendon, interference screw fixation has been the authors’ choice to achieve maximum strength so a quick rehabilitation protocol can be used. It has been shown that early active motion is preferable and can decrease the rehabilitation time. It is the authors’ preference to perform a transosseous tensioning technique.

POSTERIOR TIBIALIS TO PERONEUS BREVIS TRANSFER
Although this transfer is seldom used, it is considered when the cavovarus foot deformity presents with a strong anterior tibialis; thus, the deformity mainly consists in an adductovarus without a loss in dorsiflexion strength. For this transfer, the posterior tibial tendon harvest is performed as already described, and then it is passed deep to the deep posterior muscle compartment of the leg and recovered through the lateral retromalleolar incision previously described for the peroneus longus to brevis tenodesis.

The authors have obtained a better balanced foot when the anterior tibialis and the peroneus longus tendons are sutured to the posterior tibial tendon. With the appropriate tension added with these tenodeses, an inversion and eversion control is achieved, thus, producing a bridle effect.

TENDON TRANSFERS TO AID IN DORSIFLEXION POWER
When the hindfoot inversion tendency has already been corrected, the next issue to correct is the loss of active dorsiflexion power. This loss should have already been treated at this stage in the authors’ strategy, but sometimes additional transfers have to be performed to reinforce the action of the posterior tibialis transfer in allowing active dorsiflexion of the ankle. This surgical decision has to be made preoperatively when the posterior tibialis is a weak muscle (less than grade 3) or when performing revision surgery if a previous transfer has failed in achieving active dorsiflexion. In these cases, the in-phase transfers that can be added are the extensor hallucis longus or the extensor digitorum longus to the dorsal midfoot. These tendons are harvested in the dorsum over the midfoot and secured over the cuneiforms through bone tunnels using biotenodesis screws. The second option is using out-of-phase transfers, which can be used if the extensors previously mentioned are weak or if the dorsiflexion loss is the main symptom and the posterior tibialis transfer has already been made. These transfers are more commonly used in spastic equinovarus deformities. Out-of-phase transfers include the flexor hallucis longus and the flexor digitorum longus tendon, which can be transferred as one unit or isolated. They are transferred through the interosseous membrane and sutured to the anterior tibialis or fixed to the cuneiform bones.

ANTERIOR TIBIALIS TO CUNEIFORMS
This transfer is mainly used after the hindfoot has been corrected and residual
midfoot supination is present. The anterior tibialis is generally weak, but it can be part of the
BRIDLE PROCEDURE
The bridle procedure has been described by Rodriguez and is particularly useful when there is a severe peroneal muscular deficit. It consists of transferring the posterior tibial tendon and adding the peroneus longus and tibialis anterior. The posterior tibial tendon is passed through the tibialis anterior after passing through the interosseous membrane (similar to posterior tibialis to cuneiform transfer). Then the peroneus longus is harvested by a lateral incision over the peroneal tendons, cutting it as proximal as possible and retrieving it through a distal approach just proximal to the base of the fifth metatarsal. It is then transferred subcutaneously from lateral to anterior and deforming forces present that contribute to midfoot supination. Whenever the midfoot or hindfoot remains unbalanced after the transfers already mentioned and the anterior tibialis presents with a relative force of grade 3 or greater, consideration can be given to this transfer.

SUMMARY
Although not all cavovarus deformities are the same, most of them are related to Charcot-Marie-Tooth disease and inevitably progressive. The challenging cavus foot reconstruction must always include tendon transfers to prevent future deformities, and a careful surgical technique must be used to avoid complications and to increase the success rate.