When approaching hindfoot deformities, we must remember the combination of forefoot driven hindfoot deformities. Every hindfoot malalignment case will have some sort of compensation given by the midfoot-forefoot, and this has to be taken into consideration when correcting the deformity. The general approach should be to identify the malalignment, either a hindfoot valgus or varus, having in mind that every valgus of the hindfoot correlates to an internal rotation of the talus and therefore of the talonavicular joint with an eversion at the subtalar joint, and every varus relates to an external rotation of the talus and its associated talonavicular joint, with an inversion at the subtalar joint. This malalignment will have to be compensated by the midfoot and forefoot in order to obtain contact between the ground and the foot, and consequently, a supination of the forefoot will accompany a valgus hindfoot and a pronation of the forefoot will accompany a varus hindfoot. The deformity, once identified, has to be evaluated in its location and severity in order to decide which joints are contributing the most to it. The condition of those joints has to be evaluated next to decide if they are arthritic or not. The main goal in surgery should be to realign first the bony anatomy, trying to push slightly the limit of normal skeletal alignment. Generally speaking, healthy joints should be saved and deformities corrected through osteotomies and ligament reconstruction, and arthritic joints can be fused and the deformity corrected along with the fusion.

Hindfoot Valgus

Hindfoot Valgus malalignment refers to a valgus deformity at the ankle/subtalar joint. Nevertheless is an over-simplification to refer to it as just as a valgus deformity. It is really a multiplanar deformity in the sagittal, coronal and rotational planes. It can be located at the supramalleolar/ankle joint (post-traumatic, peritalar instability, lateral distal tibia artritis), at the subtalar joint (flatfoot, peritalar instability) and at the talonavicular joint (flatfoot, spring ligament rupture). The talus medially rotates over the calcaneus, with a compensatory midfoot supination to achieve a plantigrade foot. Most of these cases of hindfoot valgus are asymptomatic. When they become symptomatic the initial treatment is focused on exercises (tibialis posterior, achilles), insoles (over the couter, custom molded, AFO) and pain medications. After 3 months of non operative treatment, it is a general recommendation to
propose surgery.

The strategies to address the valgus hindfoot malalignment should be based on an extensive and detailed analysis of the patients extremity alignment and joint mobility. The analysis should start by ruling out any genu varum (or any extremity mechanical axis deviation) that could be the cause of the foot valgus compensatory deformity. The next step should consider the foot and ankle as a unit. The analysis should start from proximal to distal addressing joints mal alignment and stiffness. This means that patients with hindfoot valgus alignment should be treated with osteotomies or arthrodesis which achieves a slight varus tendency, so as to have a protective mechanical effect over the medial ligaments of the ankle and the foot.

Starting with the supramalleolar analysis, a deformity should be ruled out with AP/L ankle views. If there is more than 5 degrees or a lateral distal tibial angle of 85 degrees or less, a valgus deformity is present and has to be part of the surgical plan. The apex of the deformity has to be identified. Once it is located, a closing or opening wedge at the supramalleolar tibia has to be planned, correcting at least the same amount of degrees of the deformity (1).

Next step is to address the subtalar joint. A saltzman view will help with this evaluation. If there is a valgus hindfoot alignment, a correction in this area is in order. If the joint is mobile without arthritis changes on x-rays, a varizating calcaneal osteotomy is recommended. On the other hand, if there is a stiff and/or arthritic joint, a varizating subtalar arthrodesis is the technique of choice, where we also add a lateral column lengthening effect leaving the calcaneus slightly anteriorly displaced in relation to the talus, in order to achieve a varizating and column lengthening effect.

The subtalar joint cannot be separated from the Talonavicular (TN) joint. They have to evaluated as a unit. The TN joint alignment is evaluated in AP and L foot views. This will show if there is an uncovering of the talus greater than 30-40% and an increased talar declination angle. If this is encountered, and healthy joints are present where we want to preserve joints and no subtalar fusion is being considered, a calcaneal neck lengthening procedure should be performed (2). Though normally performed, adding a tibialis posterior tendon and/or spring ligament repair do not necessarily give substantially better outcomes.

A relatively new concept was introduced by Hintermann, called peritalar instability. This is a new concept that has received almost no attention except in cases where traumatic peritalar dislocations are present. No studies are out there that deal with chronic peritalar instability, until recently (3). Hintermann described patients with peritalar instability where the dysfunction occurs on all the structures surrounding the talus, namely the subtalar, and talonavicular joints. This concept encompasses the idea of an intrinsic ankle and subtalar medial instability as the cause for the deformity, not being an underlying bone deformity the (solely) cause for the deformity. Depending on the patient, the subtalar joint can compensate or not in valgus or varus orientation, thus differentiating peritalar instability in varus or valgus types. This can be identified on x-rays showing slight talus/calcaneus shifts in their relative position. The importance of this diagnosis is that peritalar instability can never be corrected only through the ankle joint. The current recommendation is to perform corrective osteotomies to achieve an aligned mechanical axis. Osseous balancing through supramalleolar osteotomies, calcaneal varizating osteotomies, lateral column lengthening procedures, and subtalar arthrodesis have to be considered as they supposedly will be more reliable for a long lasting rebalancing procedure. The authors fully agree on this concept and thus postulate a complete osseous realignment.
before a medial ankle ligament reconstruction is planned when treating these types of patients. There is still no good soft tissue surgery for this problem.

Finally the forefoot has to be addressed. The supination deformity that appears as a compensatory deformity to the hindfoot valgus has to be addressed in case it is a stiff deformity. A cotton osteotomy or a lapidus procedure could be performed to help with achieve a plantigrade forefoot after the hindfoot correction.

**Hindfoot Varus**

A said before, every hindfoot varus relates to an external rotation of the talus and its associated talonavicular joint, with an inversion at the subtalar joint. This malalignment will have to be compensated by the midfoot and forefoot in order to obtain contact between the ground and the foot, and consequently, a pronation of the forefoot will accompany a varus hindfoot. In cavo varus feet, most of these procedures pretend to correct the static deformity, but the dynamic deformity must also be addressed by tendon transpositions. This is due to the belief that tendon imbalance present in varus patients is an important component of the deformity, idea which is not present in valgus hindfoot where a failure in soft tissue support would be the origin of the deformity.

When performing the preoperative planning, the apex of the deformity must be identified in order to choose the correct surgical procedure for each case. The contribution of the forefoot to the hindfoot deformity has to be evaluated, as in the majority of cases the main deformity is in the first metatarsal, so a dorsiflexion osteotomy of the first metatarsal should be performed in almost every case (forefoot driven hindfoot varus). For most cavo-varus foot deformities that need surgery, some form of calcaneal osteotomy is also necessary. For this purpose the Coleman block test is performed as well as clinical assessment of forefoot flexibility.

We presented an algorithm for hindfoot, midfoot and forefoot correction (4). We propose this step by step protocol to correct the deformity as a surgical guide and not as a recipe because every deformity is unique. Analyzing the deformity from proximal to distal, significant varus alignment located at the distal tibia or at the ankle joint should be addressed through supramalleolar osteotomies especially if early signs of osteoarthritis are present. Frequently lateral and/or medial ankle instability is present which has to be evaluated preoperatively and intraoperatively, and adequate fixation devices have to be used as anchors or biotenodesis screws in order to reconstruct the medial deltoid or the lateral ankle ligaments.

The subtalar area has to be evaluated next, and depending on its flexibility a corrective subtalar fusion should be performed, or a calcaneal osteotomy. The classic Dwyer osteotomy is very popular, but complete correction is obtained just in mild deformities. A lateral sliding calcaneal osteotomy is usually preferable for most cases (5). A lateralizing calcaneal osteotomy will realign the hindfoot varus during heel strike and will lateralize the moment arm of the achilles tendon during toe off. The "L" osteotomy described by Pisani (6) and modified in a "Z" by Hintermann allows us an even more effective correction than the lateralizing closing wedge osteotomy for realignment of severe hindfoot varus. Since this osteotomy is more proximal than Dwyer the correction of the tuberosity is more effective. This “Z” calcaneal osteotomy has become our preferred osteotomy to correct hindfoot in severe cavus foot because it is extremely powerful offering a big contact surface for easy and stable fixation with two 7.0 cannulated screws.
Generally the next step is to address the first metatarsal deformity. As it has been described by Manoli (7) every subtle cavus feet needs a first metatarsal osteotomy, because plantar flexion of the first ray is always present. We classically perform a dorsiflexion osteotomy of the first metatarsal removing an oblique wedge off the dorsum of the metatarsal.

Once the apex of the deformity is corrected, flexibility and tendon balance must be addressed as it was previously analyzed. This evaluation must take into consideration medial soft tissue release and lateral ankle ligament reconstruction. No correction will last overtime if muscle power is not balanced. For most patients peroneus longus to brevis transfer is necessary. For some others, some form of adding dorsiflexion power to the ankle is necessary, like posterior tibialis tendon transfer to the dorsum of the foot.

References

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