RELIABLE ANATOMICAL MARKER FOR THE EVANS CALCANEAL OSTEOTOMY

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The effectiveness of the Evans osteotomy in the treatment of adolescent collapsing pes plano valgus and posterior tibial tendon dysfunction has been well documented in the literature (1-6). Although initially described by Evans to treat rigid pes plano valgus, the Evans osteotomy has become a mainstay in the treatment of the flexible flatfoot. The versatility of the Evans osteotomy is derived from its extra-articular orientation and its ability to provide multi-planar correction (2).

The Evans osteotomy serves to lengthen the lateral column and realign the midtarsal joint, while effectively reducing forefoot abduction and calcaneal eversion (1-10). Medial arch stabilization is then achieved secondary to the tensioning of the long plantar ligament (LPL). Plantarflexion of the forefoot is seen secondary to the tension placed on the LPL and peroneus longus (2). Dinucci et al noted that although as graft size increased, so did pressure on the LPL. Grafts greater than 6 mm were noted to have no additional corrective capacity without compromising the LPL (24). Relocation of the talonavicular joint (TN) is also noted. Primary advantages include consistent radiographic correction with improvements of dynamic pronation (2, 4, 5).

Radiographic findings consistent with successful Evans osteotomy correction are noted to be triplanar. Sagittal plane correction includes increased calcaneal inclination. Tension placed along the LPL will account for some plantaflexion of the forefoot, but often additional procedures are required to fully reduce the supinatus. Transverse plane correction consisting of decreased calcaneocuboid joint angulation and increased talar head coverage is noted. In the frontal plane, calcaneal valgus is drastically decreased.

Optimal placement and orientation of the Evans calcaneal osteotomy to avoid injury to adjacent anatomical structures continues to be debated within the literature. Variations in anatomy further compound this. There have been 3 different arrangements in regard to calcaneal facet morphology described (7). These include the presence of 3 distinct facets, a confluence of the anterior and middle facets with a distinct posterior facet, or a confluence of all three facets (7). Regardless of the number of facets present, complications resulting from violation of the middle facet can be particularly detrimental (2-10).

In contradiction to early anatomy texts, many studies have indicated that a majority of calcanei do not have discreet anterior and middle facets, thus increasing risk of possible transection during the Evans osteotomy. As early as 1904 Laidlaw reported that in an examination of 750 calcanei, 68% exhibited confluence of the anterior and middle facets (14). Sarrafian reported similar findings noting 64% of calcanei examined (n = 50) had conjoined facets (15). Hyer et al, in the largest study of note (n = 755), observed 56% had conjoined middle and anterior facets (9). In one study, Bunning and Barrett looked at a variety of both adult and fetal calcanei from European, African, and Indian populations. They concluded a possible genetic predisposition in regards to facet morphology, as the European population had a statistically significant higher presence of three distinct facets as compared to their African and Indian counterparts who were more likely to have only 2 discrete facets. Subsequently, a study examining the variations in Egyptian calcanei (n=200) reported that three discrete facets were seen in 40% of specimens, conjoined anterior and medial facets were seen in 49%, and one singular conjoined facet was noted in 11% (17). Conjoined facets have also been associated with higher frequencies of arthritic changes associated with joint instability than did calcanei with discrete facets (26)

Several studies have reported on the distance between the anterior and middle facets when they are distinct entities. Gupta and Gupta were first to describe variance among the distance between the two distinguished facets when present. They noted that of the 401 Indian calcanei that they examined, 67% had a distinct anterior and middle facet. Of these (n = 268), 9% showed a distance of less than 2 mm between, 4% had a distance between 2-5 mm, and 13% had a distance greater than 5 mm between. Campos and Pellico also documented this distance. In a study of 176 calcanei 46.5% maintained separate facets. Of these, 3% had a distance less than 2 mm, 21% maintained a distance between 2-5 mm, and 16% had greater than 5 mm between the facets. Most recently, Hyer et al noted the average distance between the anterior and middle facets was 3.85 mm (range 0.38-12.59)

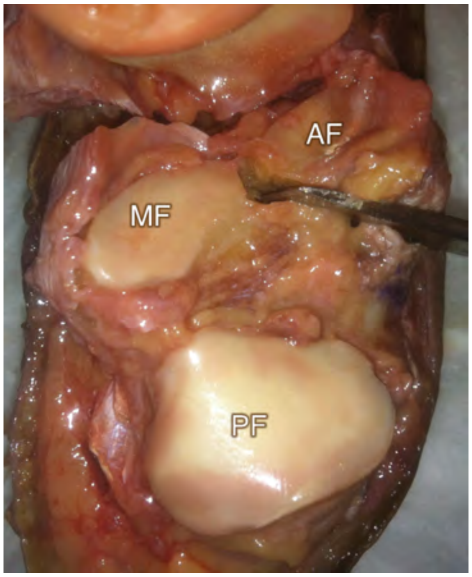

Figure 1. Facet number and violation of the facets.


Figure 2. Violation of the middle facet results in compromising a major load-bearing area of the rearfoot.

The importance and function of each of the individual facets has been noted. Wagner and Sangeorazan reported that despite the overall smaller area of contact compared to the posterior facet, the anterior and middle facets supported 63.3% of the load carried by the posterior facet (20). Della Rocca et al concluded that as pressure increases through the ankle and rearfoot, the middle facet sees disproportionately high loads, attesting to the importance of a sound middle facet (21). Traumatic fracture of the sustentaculum tali (ST) and thus possible violation of the middle facet have been associated with flexor hallucis longus tendon damage, tarsal tunnel syndrome, and nonunion of the area (21, 22). Although listed in the literature as complications resulting from a traumatic mechanism of injury to the ST, it can be inferred that iatrogenic transection would lead to this as well (21, 22).

Evans initially indicated that the osteotomy should be 1.5 cm proximal and parallel to the calcaneal cuboid joint (CCJ). Others have since indicated alternative distances for placement ranging from 4-1.5 mm (9-13). Most recently, Bussewitz et al reported that 1.3 cm was the appropriate distance from the CCJ for osteotomy initiation to avoid transection of the middle facet. This can be a difficult distance to estimate during the surgical procedure, resulting in inappropriate osteotomy placement. The CCJ is typically well-visualized on the lateral view, as is the calcaneal sulcus (CS). We propose that an osteotomy placed centrally between these two structures will yield reliable placement of the Evans osteotomy, ultimately decreasing risk of injury to surrounding structures.

METHODOLOGY

Ten fresh-frozen, adult, below the knee cadaveric limbs were obtained for dissection. The CCJ and the CS were identified radiographically. A Freer elevator was used to denote a proposed osteotomy between these 2 structures. Following a standard dissection, osteotomies were then placed 1 cm proximal and parallel to the CCJ. Radiographic location of the CS was confirmed, as were the CCJ and the osteotomy. The calcaneus was then disarticulated from the leg to allow visualization of the dorsal surface of the calcaneus. Digital calipers were used to then measure the distance from the CCJ to the CS, the distance from the osteotomy to the CS, and the osteotomy to the CCJ. Calcanei were then disarticulated allowing visualization of the dorsal calcaneus. Facet number and violation of these facets were then recorded (Figure 1).

RESULTS

Of the ten cadavers surveyed, 5 were left legs and 5 were right. Four of 10 calcanei exhibited conjoined facets, the remaining 6 were noted to have distinct anterior and middle facets. We observed an average distance of 20.47 mm from the CCJ to the CS, and an average distance of 9.5 mm from the osteotomy to the CS. The middle facet was injured in 2 of 10 cadavers that exhibited distinct facets, and 4 of 10 facets were violated on the conjoined specimens.

DISCUSSION

Although the Evans osteotomy is a reliable and reproducible procedure, it can be wrought with complications. Among the possible complications previously listed, the concern for violation of the middle facet is perhaps the most detrimental. Violation of the middle facet results in compromising a major load-bearing area of the rearfoot (21). These patients typically have poor outcomes and are associated with arthritis and potentially peroneal tendon spasm (Figure 2). As Hyer et al reported a rate of conjoined facets of 56%, this is a particularly alarming consequence (10).

Raines and Brage were first to specifically examine structures at risk during the Evans osteotomy (22). They initiated the osteotomy at 5, 10, and 15 mm proximal to the CCJ in 20 cadaveric specimens. They noted that the peroneal tendons and sural nerve were at risk during the more proximal osteotomies. Medial structures including the tibialis posterior, flexor hallucis longus, flexor digitorum longus, and medial plantar nerve were consistently at risk, but more so during the more proximal osteotomies. They found that 10 mm proximal to the CCJ was the most advantageous initiation point to avoid damage to the anterior and middle facets (22).

Osteotomies less than 10 mm were noted to have the inadvertent potential of violating the medial aspect of the CCJ. Hyer et al reported a distance of 1.3 cm as a site for appropriate osteotomy initiation in order to best avoid facet violation (10). This distance was later used by Bussewitz et al in their series of 10 cadavers. They noted conjoined facets in 2 of 10 specimens. Violation of the facets was avoided 44% of the time. They also noted that the osteotomy should be oriented in a postero-lateral to antero-medial direction (22).

We were able to avoid transection of the facets in 40% of specimens. This is line with the rate noted by Bussewitz. We propose that the above described technique is a quick and reliable method of finding this area intra-operatively. Mosca has described his modifications to the Evans procedure, which includes starting at 1.5 cm proximal to the CCJ. He advised that the middle facet be located with a Freer elevator to avoid transection. Additionally a proximal lateral to distal medial direction was advocated (25). Although a reasonable technique, concern for the increased time and soft tissue dissection needed to accomplish this is a down side.

In conclusion, the Evans osteotomy is an incredibly versatile and effective osteotomy in the treatment of flatfoot deformity. There is significant risk to the middle facet during osteotomy execution. This is especially increased in the patient with conjoined facets. A close examination of the literature reveals conjoined facets are much more common than initially anticipated. The literature has suggested that the Evans calcaneal osteotomy be placed between 1-1.5 cm proximal to the CCJ. This can be a difficult distance to reproduce in an operative situation. We propose that osteotomy initiation should be placed centrally between the CCJ and the CS. This will reliably place the osteotomy at a level less likely to cause insult to surrounding anatomic structures.

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