The Crossover Second Toe Deformity: Commonly Seen But Little Understood

There are multiple surgical approaches but further studies are needed.

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Crossover second toe deformities are one of the most common but least understood pathologies that foot and ankle surgeons deal with on a routine basis (Figure 1). As an example, if you were to do a Pubmed search using the key words "hallux valgus," you would find over 3,000 articles. Using the keywords "crossover toe," you have only 86 articles, and many of them are on horses. There is not enough research or long-term data to fully understand or appreciate the complexity of this common deformity. This article is the author's approach to the crossover deformity.

The Deforming Forces

Before discussing the surgical approach to this problem, we need to look at the deforming forces behind this. Coughlin et al dissected 16 cadaver specimens with crossover second toe deformities to see what soft tissue pathology was involved at the metatarsophalangeal joint[1]. Other than associated pathology (hallux valgus or hallux rigidus), the specific structures they were evaluating were the plantar plate and the lateral collateral ligaments. The lateral collateral ligaments were completely intact in 10 of the 16 specimens. The plantar plate, on the other hand, was either completely or partially torn in all 16 specimens. The goal of any surgical procedure is to take the pressure off of the plantar metatarsophalangeal joint structures. This is accomplished through eliminating any equinus force, first ray instability, and structural pressure from an elongated second metatarsal.

The vast majority of patients will have gastrocnemius equinus and not gastroc-soleal equinus, although this needs to be specially tested for as some patients will present with a tight Achilles' tendon. The preferred approach for gastrocnemius equinus is through a medial proximal gastrocnemius recession. This has the advantages of not performing a form of an Achilles lengthening by cutting into the fibers of the soleal aponeurosis, and ease of positioning. The patient is placed in a supine position with the heel on a well-padded mayo stand and the knee extended (Figure 2). An approximately 3 cm incision is made at the junction of the gastrocnemius medial head and the aponeurosis. This is identified by manually dorsiflexing and plantarflexing the foot and feeling the tight band of the aponeurosis. The dissection is deepened down to the fascia, being aware of the location of the saphenous nerve and vein. The fascia is incised longitudinally, not plunging the knife blade into the muscle belly. The separate junction between the soleus and gastrocnemius muscles can be found be placing your index finger proximally along the incision. To confirm proper separation, you can plantarflex and dorsiflex the foot and feel the two muscles squeeze your index finger. Gently sweep posterior along the gastrocnemius aponeurosis. Place a retractor between the gastrocnemius aponeurosis and soleus to pull the soleus muscle to isolate the aponeurosis (Figure 3). With the knee extended and the ankle maximally dorsiflexed, take a 15 blade and gently release the medial one-third, taking care not to plunge deep into the muscle. Next, take a mayo

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scissors and, opening the tip of the scissors slightly, glide across the remaining tight aponeurosis. Think of cutting wrapping paper by placing tension on the paper and then let the scissors cut the paper without opening and closing the handles. I release the aponeurosis until I can dorsiflex the ankle past neutral position. Check for the plantar tendon as well. This is also an extremely tight structure and needs to be released, too. With the tight structures released, layered closure is performed, making sure not to entrap the saphenous vein and nerve or suture the muscle belly to the fascia.

The Unstable First Ray

Now, the unstable first ray is addressed. The procedure the author prefers is a first tarsometatarsal arthrodesis to help stabilize the tripod of the foot. If there is first metatarsophalangeal joint pathology, such as hallux valgus or hallux rigidus, this is addressed at this time as well. For the first tarsometatarsal exposure, a dorsomedial approach is performed. Dissection is deepened to carefully identify and retract the medial dorsal cutaneous nerve. The dorsal ligaments are released to expose the joint and a bone spreader is utilized to better access the articular surface. The author prefers to use a curettage technique to remove the cartilage (Figure 4). It is important to remember that this joint is approximately 3.0 cm deep and is a "c" shape. Avoid getting aggressive with resection along the lateral aspect of the interspace area between the metatarsals. Once the cartilage has been respected, a sagittal saw can be used to help approximate the fusion surfaces. While there are multiple ways to fenestrate the subchondral plate, the author prefers a "fish scale " technique using the edge of a one-quarter inch curved osteotome (Figure 5). The curved portion allows access to the plantar aspect of the joint. If the patient has increased risk factors for poor bone healing, the fusion site can be augmented with bone graft or orthobiologic. The first metatarsal is positioned on the medial cuneiform. The goal is to try and recreate the tripod but not over-correct it. This typically is corrected by having a small step-off from the medial cuneiform to the first metatarsal. This is about a 2 mm plantar translation. Temporary fixation can be achieved by using two 0.062 inch k-wires—one

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A recent multi-center, retrospective study showed a 2.9 percent nonunion rate with compression screw and locking plate fixation[2].

Figure 2: OR positioning for medial approach gastrocnemius recession

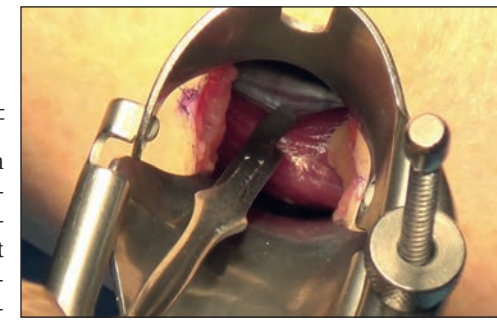

Figure 3: Isolation with retraction showing the gastrocnemius muscle and aponeurosis

Figure 1a: Crossover 2nd toe deformity with recurrent hallux valgus

Figure 1b: Preop radiographic crossover 2nd toe deformity with recurrent hallux valgus

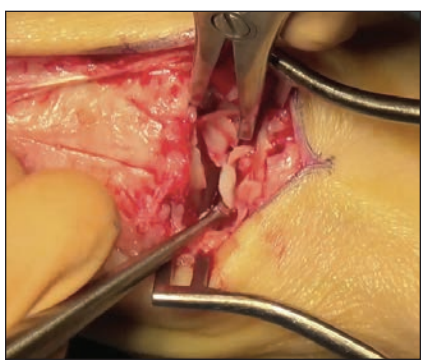

Figure 4: Curettage technique of cartilage debridement for the first tarsometatarsal arthrodesis

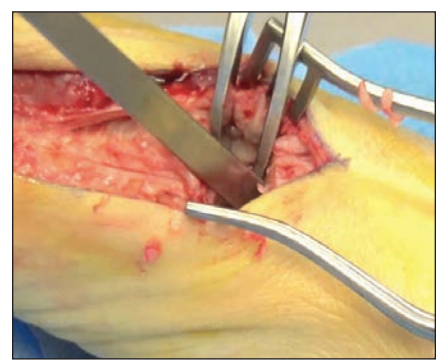

Figure 5: "Fish-scale" fenestration of the subchondral plate to prepare the arthrodesis

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placed from the first metatarsal into the second metatarsal or intermediate cuneiform (Figure 6), and the other from either the first metatarsal into the medial cuneiform or vice versa. Once alignment is confirmed both radiographically and clinically, a compression screw is placed from the dorsal first metatarsal into the plantar medial cuneiform. Aim more medial than you expected as the goal is to have the screw directly center or medial to center. The arthrodesis site is further fixated with a locking plate placed on the medial aspect. A recent multi-center, retrospective study showed a 2.9 percent nonunion rate with compression screw and locking plate fixation.[2]

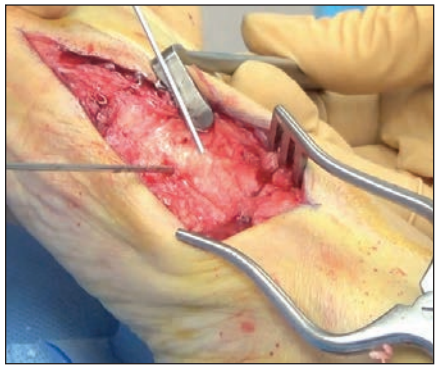

Figure 6: Temporary fixation of the first tarsometatarsal arthrodesis with k-wires

Figure 7: Oblique osteotome of the 2nd metatarsal oriented from distal-lateral to proximal-medial

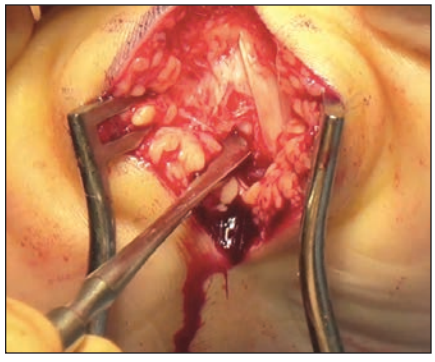

Figure 8: Plantar plate tear of the 2nd metatarsophalangeal joint with the flexor tendons retracted medially

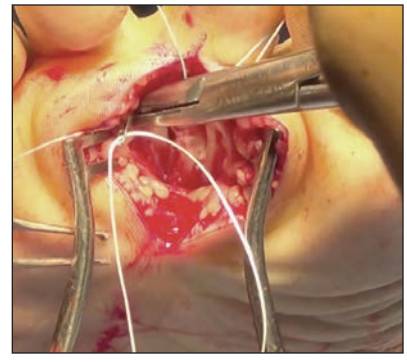

Figure 9: Suture placement from the bone anchor in the base of the proximal phalanx into the thicker plantar plate of the metatarsal

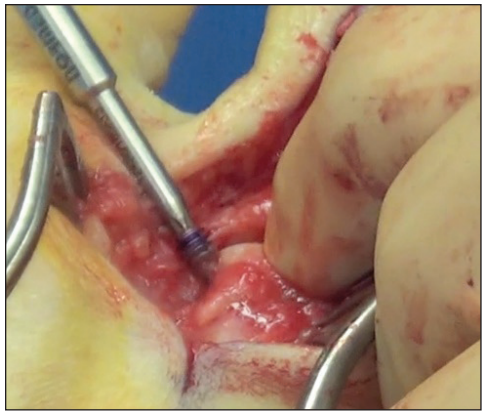

Figure 10: Screw fixation of the metatarsal osteotomy. Screw is placed from distal-medial to proximal-lateral across the osteotomy

Figure 11: Post-operative alignment of the corrected foot

The Second Toe and Metatarsophalangeal Joint

Two of the deforming forces have now been addressed. Now attention is directed towards the second toe and metatarsophalangeal joint. A linear incision is made beginning at the distal aspect of the second metatarsal and extends along the dorsal aspect of the second toe. The author prefers to start with the hammertoe deformity. The long extensor tendon is released. Proximal interphalangeal joint arthrodesis is performed via an end to end arthrodesis. While there are a variety of fixation techniques and hardware options, the author recommends a fixation technique that can incorporate the use of a k-wire. The important point now is to fixate the proximal interphalangeal arthrodesis, but do not advance the k-wire past the base of the proximal phalanx.

More than likely, the patient has an elongated second metatarsal that still needs to be addressed. Perform a second metatarsophalangeal capsulotomy, releasing the extensor hood mechanism. The condition of the plantar plate can be checked at this point. Take a freer elevator and feel the condition of the plantar plate. If the plate is intact, the freer should not be felt along the skin on the plantar surface of the foot. If the plantar plate is torn, the freer can easily be felt on the skin. If the plantar plate is torn, then a repair will be necessary.

Before the plate is repaired, the metatarsal osteotomy is performed. There are numerous osteotomies to choose from. The author advocates an oblique osteotomy for the crossover toe is an oblique decompression osteotomy of the distal metatarsal. The goals of the osteotomy are twofold. The first is to realign the parabola by slightly shortening the second metatarsal. The length of the second metatarsal is typically compared to the first metatarsal. The author finds that once the first ray is stabilized, it is better to align the second metatarsal compared to the length of the third metatarsal. The ideal position is

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to have the second metatarsal slightly longer than the third. The second goal is to bring the toe out of the medially deviated position.

The oblique osteotomy is a dorsal to plantar osteotomy. This is oriented from lateral-distal to medial-proximal (Figure 7). The lateral starting point is just proximal to the edge of the cartilage to avoid the articular surface. Make sure that the capsular tissue is freed from the lateral portion to allow for ease of shifting the capital fragment.

The key concept is that the capital fragment is moved towards the deformity. So in the case of the medial crossover second toe deformity, the capital fragment is shifted slightly proximal and medial. After the capital fragment is shifted, it is temporarily fixated with a guide wire from medial to lateral. The osteotomy and the parabola position are confirmed using intra-operative imaging. Once again, check the position of the second metatarsal with the third metatarsal. Do not fixate the osteotomy at this time.

Repairing the Plantar Plate

Now comes the repair of the plantar plate. While new techniques and instrumentation are being developed for a dorsal approach plantar plate repair, the author still uses a plantar approach. The incision is placed along the plantar second metatarsophalangeal joint. Dissection is carried down to the flexor tendon sheath. The sheath is carefully incised. The flexor tendons are usually retracted medially. The plantar plate is now visible. The tear can be directly visualized or by placing the freer from dorsal through the plantar plate tear (Figure 8). The plate will be thicker along the metatarsal compared to the base of the proximal phalanx. A 2.8 mm anchor will need to be inserted into the base of the proximal phalanx in order to facilitate advancement of the plantar plate from the metatarsal into the base of the proximal phalanx. However, the k-wire that was used to fixate the proximal interphalangeal joint arthrodesis needs to be avoided. An easy technique to ensure proper anchor placement is to take a 0.062 inch k-wire from dorsal to plantar to create your guide hole for the anchor. This will make sure the arthrodesis k-wire is avoided and that there is proper positioning of the anchor away from the joint surface, and will allow for easier insertion of the anchor. Once the anchor is placed, sutures are thrown into the metatarsal portion of the plantar plate but they are not tied at this time (Figure 9).

Reduce the second toe in the desired position, which is usually neutral to slightly plantarflexed and then advance the k-wire from the proximal interphalangeal arthrodesis across the metatarsophalangeal joint, capital fragment and into the canal of the metatarsal. This allows for a sec-

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About the ACFAS

Founded in 1942, the American College of Foot and Ankle Surgeons (ACFAS) is a professional society of more than 7,200 foot and ankle surgeons. ACFAS seeks to promote the art and science of foot, ankle and related lower extremity surgery; address the concerns of foot and ankle surgeons; ensure superb patient care; and advance and improve standards of education and surgical skill.

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ond point of fixation of the osteotomy and to hold the toe in the proper position. Check the position and the parabola using intraoperative imaging. Make sure the second metatarsal is still in the desired parabola. Sometimes the advancement of the k-wire will shorten the second metatarsal and this would need to be adjusted. Now, fixate the osteotomy either using a cannulated screw across the guide wire that was initially used to temporarily stabilize the osteotomy or remove the guide wire and place a solid screw (Figure 10). Finally, tie the suture on the plantar plate repair. Since the toe is in the position, there is no need to have someone try and hold the toe in position while it is being sutured.

The postoperative course for this procedure consists of approximately two weeks in a non-weightbearing splint.

Post-Op Course and Complications

The postoperative course for this procedure consists of approximately two weeks in a non-weightbearing splint. If everything is healing as expected, the patient is placed in a below-the-knee fracture boot and can begin weightbearing in the boot as tolerated. At eight weeks post-op, radiographs are obtained. If everything is healing as expected, the pin is removed from the second toe and the patient can begin transitioning into a shoe. Ribbon taping of the toe is recommended when weightbearing for four weeks. At 12 weeks the patient can start to advance activities as tolerated. Ribbon taping of the toe is recommended with higher impact activities. Patients are typically seen at 10–12 months post-op at this time (Figure 11).

While this procedure has worked well, there are obviously potential complications. Most commonly seen on the second toe are stiffness, chronic swelling, and scarring. Recurrence of the crossover toe is extremely rare, but there can be some elevation and lack of purchase of the toe. Extreme complication is loss of the toe. In some patients with long-standing deformities, the correction of the toe can lead to vascular insult. This can come from the procedures or even the dramatic correction of the toe position.

Post-op complications most commonly seen on the second toe are stiffness, chronic swelling, and scarring.

Crossover toe deformity is a common pathology with multiple surgical approaches. The above-mentioned procedure has worked well over the last several years for these patients. However, given the numerous procedures that are available and the lack of literature, we surely need further studies to understand this complex pathology. **PM**

References

[1] Coughlin MJ, Schutt SA, Hirose CB, Kennedy MJ, Grebing BR, Smith BW, Cooper MT, Golano P, Viladot R, Alvarez F. Metatarsophalangeal joint pathology in crossover second toe deformity: a cadaveric study. Foot Ankle Int. 2012 Feb;33(2):133-40.

[2] Prissel MA, Hyer CF, Grambart ST, Bussewitz BW, Brigido SA, DiDomenico LA, Lee MS, Reeves CL, Shane AM, Tucker DJ, Weinraub GM. A Multicenter, Retrospective Study of Early Weightbearing for Modified Lapidus Arthrodesis. J Foot Ankle Surg. 2016 Mar-Apr.

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