

Dorsal Approach for Plantar Plate Repair With Weil Osteotomy: Operative Technique

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Abstract

In recent years, the role of the plantar plate in lesser metatarsophalangeal joint stability has increasingly been recognized. Tearing or attenuation of the plantar plate often will result in crossover or hammertoe deformity with hyperextension of the MTP joint. Some patients are able to have resolution of painful symptoms with conservative treatment but for those that fail these measures, surgical fixation of the plantar plate is indicated. While, there have been some described techniques for direct repair of the plantar plate, we present a surgical technique through a dorsal approach with a Weil osteotomy which accomplishes great clinical correction of the plantar plate tear and associated toe deformity as well as relief of patient's pain. Additionally, we believe this technique is safe, efficient and reproducible.

Level of Evidence: Level V, expert opinion.

Keywords: plantar plate repair, Weil osteotomy, plantar plate tear, metatarsophalangeal joint (MTP), MTP instability, MTP synovitis, floating toe, cross-over second toe

The plantar plate has recently gained increasing attention as an important component of metatarsophalangeal (MTP) joint anatomy.² Its role in stabilization and balance of the MTP joint has been the subject of much recent study. The plantar plate is fibrocartilage tissue formed from the plantar aponeurosis and the joint capsule. The majority of the plantar plate tissue is Type I collagen, which has a diminished capacity for primary repair. It originates from the plantar surface of the proximal phalanx and inserts just proximal to the articular cartilage at the metatarsal neck. At its insertion it has a synovial attachment (Figure 1). The length, thickness, and width of the plantar plate are approximately 20 mm, 2–5 mm, and 16 mm, respectively.^{5,7} The plantar plate is composed primarily of type 1 and type 2 collagen and these fibers form a dense fibrocartilage.^{4,9} It is the primary static stabilizer of the MTP joint in the sagittal plane.² Injury commonly occurs due to trauma, inflammatory arthritis, synovitis, and inflammatory attrition, which can lead to instability of the MTP joint.²⁰

Klein et al evaluated physical exam findings and correlated these with intraoperative tears. The authors found that 95% of patients with a plantar plate tear had gradual onset of pain, edema in the plantar region of the MTP joint and a positive drawer test (also known as the Lesser Toe Lachman Test). They concluded that a physical exam is sufficient for the diagnosis plantar plate tears.¹² In our experience, patients present with both acute and chronic pain which is described

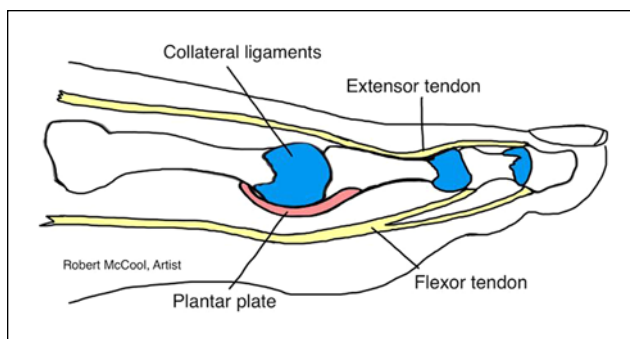


Figure 1. Illustration of the anatomic relationship between the plantar plate and other relevant metatarsophalangeal joint anatomy. Note the insertion of the plantar plate to base of proximal phalanx and synovial attachment around metatarsal neck. Artwork kindly provided by Robert McCool, MS.

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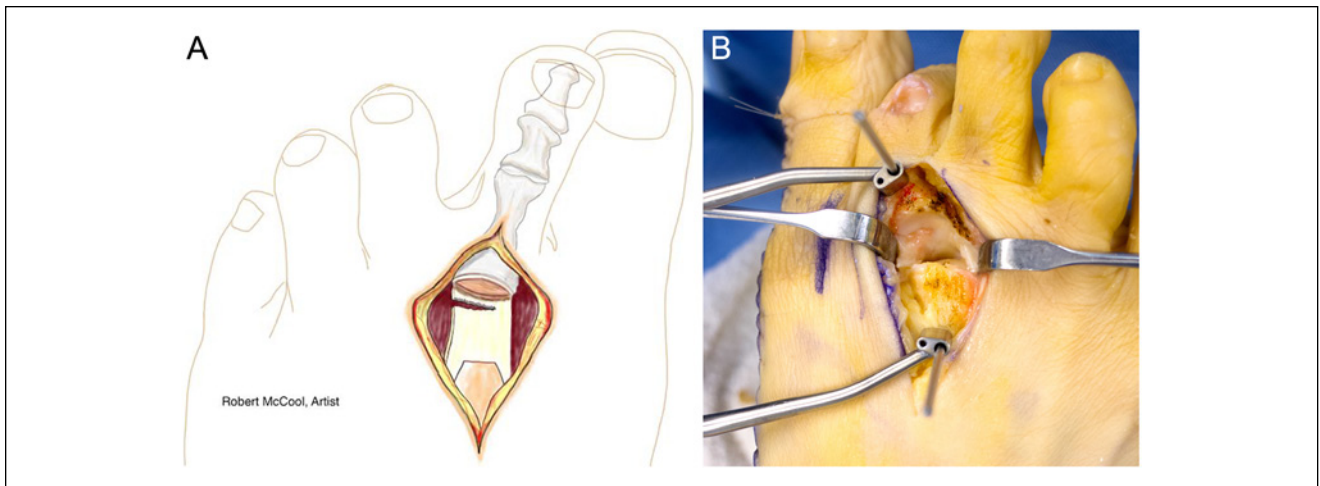


Figure 2. (A) Illustration of plantar plate tear with medial deviation of the toe. (B) Intraoperative findings of plantar plate tear. Artwork kindly provided by Robert McCool, MS.

as sharp or dull and which is exacerbated by MTP joint range of motion. Patients have subjectively described their pain as a sensation of “feeling a pebble” or having a bruise in the ball of their foot. There is often focal swelling seen around the plantar aspect of the MTP joint, and pain at the insertion of the plantar plate into the proximal phalanx.¹² In addition, the toe may subluxate dorsally and medially such that it overlaps the adjacent toe with weight-bearing (Figures 2A, 2B).

The MTP joint is evaluated in the sagittal plane using the drawer test. The drawer test requires the MTP joint to be stabilized proximally while a dorsally directed force is applied to the proximal phalanx.¹⁹ Translation of the proximal phalanx greater than 50% or 2 mm is considered a positive indication of plantar plate disruption.^{10,12} The pathologic joint may also be compared to adjacent lesser MTP joints when assessing for subtle MTP instability.

MTP joint laxity may also be identified using the Kelikian push up test.¹ This test involves application of a dorsally directed force on the plantar surface of the metatarsal head and observable reduction of the MTP joint. A positive result demonstrates medial deviation of the toe with stress. This can also be accomplished by observing the symptomatic toe with weight-bearing. The normal MTP joints from both the ipsilateral and contralateral foot should be evaluated for comparison.

Evaluation of plantar plate pathology should include standard weight-bearing AP, lateral and oblique x-rays to evaluate overall toe alignment. This allows other causes of metatarsalgia such as stress fracture, a relatively long metatarsal, Freiberg infraction, and MTP arthritis to be identified. In a recent publication by Klein et al, odds ratios revealed that patients with an intermetatarsal angle of greater than 12 degrees, medial deviation of the second toe, and splaying of the digits were more likely to be diagnosed with a plantar plate tear intraoperatively. In addition, the authors concluded

that restoring the harmonious parabola of the forefoot is important for maintenance of long-term successful repair of the plantar plate with the desired length of a second metatarsal that is 1-2 mm longer than the first metatarsal.¹³

Advanced imaging such as MRI, ultrasound, arthrography or some combination is also used to assess the plantar plate. We primarily order an MRI to evaluate the integrity of the plantar plate and to rule out avascular necrosis of the metatarsal head or stress fracture not seen on standard radiographs. MRI has been found to be both a highly sensitive and specific modality for imaging of the plantar plate.²¹ In a study by Sung et al, MRIs were obtained in 45 patients and compared with intraoperative findings. MRI was found to be 96% accurate, with 95% sensitivity, 100% specificity, a positive predictive value of 100% and a negative predictive value of 67%.¹⁸ Likewise, Klein et al compared MRI and ultrasound with intraoperative findings. Their study suggested that while ultrasound can be useful, MRI is more specific and is the preferred imaging modality when it is available.¹⁴ The benefit of ultrasound and arthrography is in their accessibility. However, it should be remembered that their accuracy is strongly operator dependent.

Initial treatment of plantar plate injury should be conservative. Nonoperative treatment includes modification of activities associated with pain, the use of orthotics, metatarsal pads, and modified shoe wear. A hammertoe sling and taping of the toe in slight plantarflexion may provide symptomatic treatment. Rocker bottom and stiff soled shoes are sometimes helpful in decreasing stress on the MTP joints with ambulation. CAM boots can also be used to immobilize the MTP joint and decrease inflammation. Finally, NSAIDs or a single corticosteroid injection into the affected joint can relieve inflammatory symptoms. The authors have found no adverse effect of a single injection given into the lesser MTP joint and usually protect toe motion after the

Table 1. Common Indications Used for Dorsal Direct Plantar Plate Repair With Weil Osteotomy.^{3,6,10,12,15}

Absolute Indications	Relative Indications
Severe lesser MTP pain with plantar plate tear, attenuation, or rupture	Lesser MTP joint drift with MTP subluxation or dislocation

Table 2. Important Tips That Enhance the Safety and Efficiency of Performing the Procedure.

Careful use of the McGlamry retractor with gentle traction on the toe avoids damage the articular cartilage
Weil osteotomy and use of a small joint distractor is crucial to visualize the plantar plate for repair
The Beaver blade is a useful instrument to detach the remaining plantar plate without inadvertently damaging the underlying flexor tendon
A suture passer or lasso is helpful in passing suture anterograde through the drill holes in the proximal phalanx. The surgeon must visualize the plantar exit site of the suture passer at the base of the proximal phalanx
Keep the K-wire in the proximal phalanx and use as a joystick to aid in suture passage and visualization of plantar aspect of proximal phalanx

Table 3. Technical Pitfalls: Some Tips to Stay Out of Trouble During Certain Portions of the Procedure.

Attempts to expose the plantar plate without performing the Weil osteotomy first will result in damage to the MTP articular cartilage and incomplete exposure of the tear
Excessive traction on the plantar plate sutures will result in suture pullout
Though a thick structure, multiple attempts at suture passage will result in shredding of the plantar plate
Be sure that your exposure allows you visualization of the plantar portion of the proximal phalanx so that the exit point of the drill holes in the proximal phalanx are easily seen
Place drill holes distal enough in the proximal phalanx to avoid penetration of the articular cartilage but proximal enough to see the exit point
Have your assistant hold the MTP joint in gentle plantarflexion as you secure and reduce the MTP joint to avoid dorsiflexion of the joint and floating toe
Avoid overzealous dissection of the plantar plate off the proximal phalanx to avoid injury to the underlying flexor tendons

injection with a hammertoe sling for 4 weeks. However, caution should be used with multiple injections into the same MTP joint to avoid potential capsular laxity and even dislocation of the toe. Only after conservative treatment has proven ineffective do we explore operative options.

Historically, the most common operative procedures to address instability at the MTP joint are the Weil osteotomy,

Girdlestone–Taylor flexor to extensor tendon transfer, or a combination of the 2 procedures. The Weil osteotomy, as a shortening osteotomy, decompresses the MTP joint while preserving joint integrity. It is used to treat painful subluxation or dislocation of the toes as well as to address painful metatarsalgia in the patient with a relatively long lesser metatarsal. The associated complications of the Weil osteotomy are transfer metatarsalgia, loss of motion through the MTP joint, potential for nonunion and the floating toe.⁸

Although the Girdlestone–Taylor or flexor-to-extensor tendon transfer is primarily done for flexible hammertoe and claw toe deformities, it also addresses hyperextension at the MTP joint by functioning as an internal brace to prevent dorsiflexion of the toe. The operative goal is realignment of the proximal phalanx with the metatarsal head to make the joint congruent again. Complications- including swelling, PIP joint stiffness, hyperextension of the DIP joint, and recurrence of the deformity-have been described.¹¹ Myerson and Jung evaluated 64 feet in 59 patients with second MTP instability treated with a flexor to extensor tendon transfer. Twenty-five patients were satisfied with the procedure and 14 patients were unhappy with their outcome. This study illustrated the potential problems and patient dissatisfaction with the flexor to extensor tendon transfer.¹⁵ Coughlin reported on a similar group of athletic individuals with documented instability of the second MTP joint treated with a flexor to extensor tendon transfer. Five of 7 patients reported their outcome as good to excellent (71%).³ This procedure remains a useful adjunct as a salvage procedure for failed plantar plate repairs or those that do not have sufficient plantar plate available for repair.

In the past, these previously described procedures allowed us to improve patient function with an indirect approach to operative correction by addressing the deformity without addressing the underlying cause of pathology (plantar plate disruption). The goal of treatment for MTP instability is realignment of the proximal phalanx with the MTP joint. Below we describe a technique for decompression of the MTP joint and direct repair of the disrupted plantar plate. We believe this technique to be beneficial in treatment of MTP joint instability and pain because it directly addresses the underlying cause of this problem: rupture or attenuation of the plantar plate.

Indications

The dorsal approach for direct plantar plate repair is indicated as a primary procedure for patients with severe pain at the lesser toe MTP joint due to plantar plate tear, rupture or attenuation who have failed conservative management. Drift of the lesser toes with MTP joint subluxation or dislocation is also a relative indication for the procedure. This procedure is occasionally employed to correct the cross over second toe deformity in severe hallux valgus cases. This procedure is performed in



Figure 3. (A) Preoperative clinical evaluation showing planned webspace incision and medial drift of the second toe. (B) preoperative AP radiograph.

conjunction with a Weil osteotomy for visualization and repair of the plantar plate and to address concomitant pathology.

Contraindications

Contraindications include absence of plantar plate pathology, conditions that preclude success of soft tissue healing such as inflammatory arthropathies, neurologic disorders, active local infection, poor peripheral vascularity, and medical conditions that preclude elective operative interventions. In patients that have a chronic dislocation of the MTP joint, there may not be adequate plantar plate to allow for this technique to be utilized and a flexor-to-extensor tendon transfer may be necessary.

Operative Technique

1. Plantar plate repair is performed under general anesthesia with a supplementary ankle block or in some cases a popliteal block. The patient is positioned supine with the foot in neutral rotation. A thigh tourniquet or an ankle Esmarch is used.
2. A dorsal longitudinal incision approximately 4 cm in length is centered over the affected MTP joint. If 2 adjacent MTP joints are to be addressed, a slightly larger incision is made within the web space of the

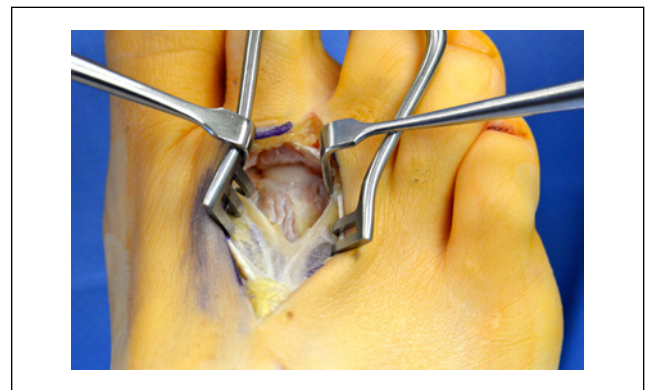


Figure 4. Intraoperative view of second MTP joint after capsular release.

3. A longitudinal capsulotomy is performed at the MTP joint. The capsule and collateral ligaments are released off the base of the proximal phalanx dorsally (Figure 4).

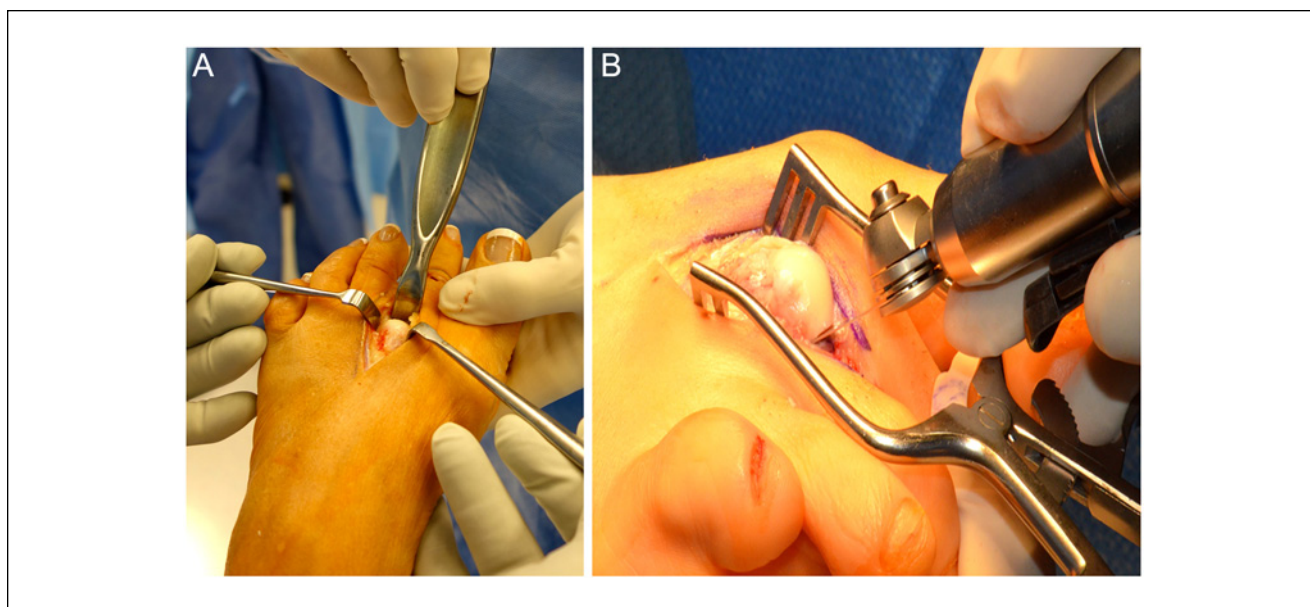


Figure 5. (A) A McGlamry elevator used to release proximal plantar plate. (B) A plantar condylectomy is performed to create cancellous surface for plantar plate healing.

4. A McGlamry elevator (Sklar, West Chester, PA) is used to release the proximal plantar plate where it has a synovial attachment to the metatarsal metaphysis (Figure 5A). Care is taken to avoid damage to the articular cartilage when inserting the McGlamry, which is accomplished by applying axial traction on the toe during insertion. The McGlamry is left in place to protect the plantar tissues and a small (1-2 mm) plantar metatarsal head condylectomy is performed (Figure 5B). The rationale for performing a plantar condylectomy is to create a bleeding cancellous surface for postoperative scarring of the proximal synovial attachment of the plantar plate. In addition, as we are performing a Weil shortening osteotomy, this condylectomy may counter the plantar translation that occurs as the metatarsal head slides proximally. Another option to accomplish this same goal would be to stack 2 saw blades or resect a small wedge of bone when performing the Weil osteotomy. However, the plantar condylectomy remains our preference as it is reproducible and creates some bleeding cancellous bone for reattachment of the proximal capsule.
5. The Weil osteotomy is then performed 1-2 mm below the dorsal metatarsal articular cartilage at an angle parallel to the weight-bearing surface of the foot.
6. The metatarsal head is then shifted proximally the desired distance (5-10 mm) with a metatarsal head pusher and secured with a 0.062-inch Kirschner wire. Care should be taken to not penetrate into the

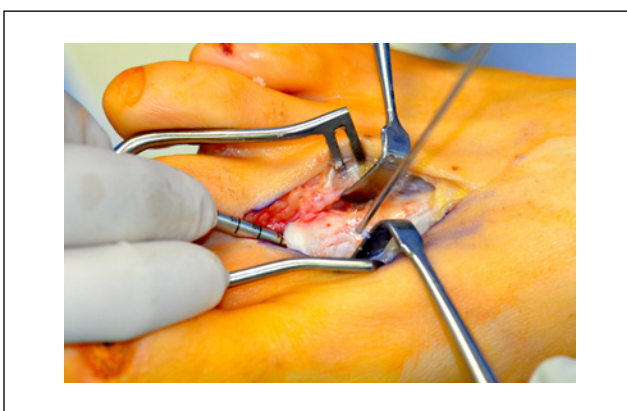


Figure 6. Metatarsal head is translated proximally after Weil osteotomy and secured provisionally with K-wire.

- plantar soft tissues with the Kirschner wire or it may be difficult to adequately distract the joint for maximum visualization. Two to 3 millimeters of the dorsal shelf of bone is then excised to assist in visualization of the MTP joint and plantar plate (Figure 6).
7. An additional 0.062-inch Kirschner wire is placed in a dorsal to plantar direction 5-mm distal to the articular surface of the proximal phalanx. A small joint distractor is used to visualize the joint and plantar plate (Figure 7).
 8. The plantar plate is inspected and location as well as type of tear is noted. Most commonly, an incomplete tear is noted at the insertion of the plantar



Figure 7. The small joint distractor allows for excellent visualization of the plantar plate after a small dorsal shelf of metatarsal bone is removed with a rongeur.

plate into the base of the proximal phalanx. In these cases, the plantar plate tear is completed using a Beaver blade (Beaver-Visitec, Waltham, MA). It is important to also release the collateral ligaments. Doing so assists the angular correction of coronal plane deformity and allows for placement of instruments necessary for passing sutures. Careful elevation of the plantar plate off the flexor tendons further mobilizes this structure for repair (Figure 8). In rare cases, a longitudinal split tear is encountered. When a split tear is found, a primary side-to-side repair with simple interrupted absorbable sutures is performed.

9. After mobilization of the plantar plate, a kit including the Mini Scorpion DX loaded with 0-Fiberwire (Arthrex, Naples, FL) is used. The suture is passed through the plantar plate twice to create a mattress suture in the plantar plate. At the surgeon's preference, an additional mattress suture is used to reinforce the construct (Figures 9A-C).
10. Remove the small joint retractor while both Kirschner wires are left in place. The Kirschner wire in the proximal phalanx is utilized as a joystick that allows the surgeon to plantarflex the joint. This improves visualization as 2 oblique holes are drilled from dorsal to plantar in the proximal phalanx using a 0.062-inch Kirschner

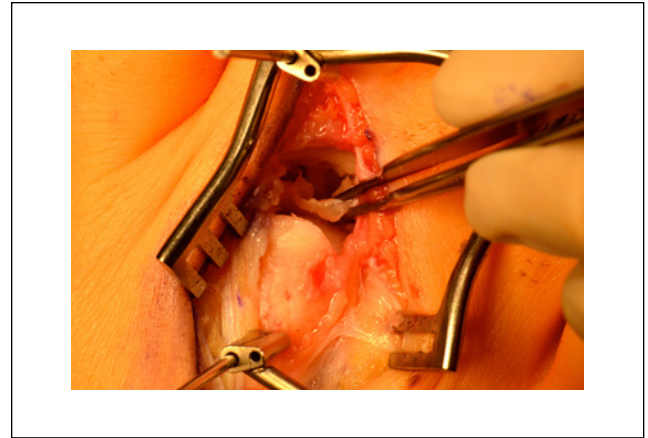


Figure 8. The plantar plate is carefully released from its proximal phalanx attachment taking care not to cut the underlying flexor tendons.

wire. These drill holes can be placed in parallel or cross fashion while avoiding violation of the articular cartilage of the proximal phalanx. Plantarflexion of the phalanx is critical for visualizing the exit point of the Kirschner wires plantarly (Figure 10).

11. A suture passer is threaded from dorsal to plantar through the drill holes to retrieve the sutures in the plantar plate and deliver suture limbs through each drill hole to the dorsal surface of the proximal phalanx (Figures 11A-C).
12. The 0.062-inch Kirschner wire in the Weil osteotomy is removed and the metatarsal head relocated into the desired final position with 2-3 mm of shortening being most typical. A 2 mm screw is used to secure the osteotomy, while the metatarsal head is held reduced with a hemostat that prevents rotation (Figure 12).
13. Once the osteotomy is secured, the Kirschner wire in the proximal phalanx is removed. The toe is held reduced in 15 degrees of plantarflexion through the MTP joint to allow for any coronal plane deformity to be corrected. The sutures are then tied over the dorsal aspect of the proximal phalanx (Figures 13A, 13B).
14. The appropriate alignment of the MTP joint, the position of the Weil osteotomy, and overall metatarsal cascade are verified using intraoperative fluoroscopy. The clinical position of the toe is also assessed at this point. If any residual transverse plane deformity remains, reefing of the medial or lateral capsule as necessary to correct it should be completed (Figures 14A, 14B).
15. At times, a hammertoe deformity will be present and should be repaired in a standard fashion at the discretion of the surgeon. Residual hyperextension

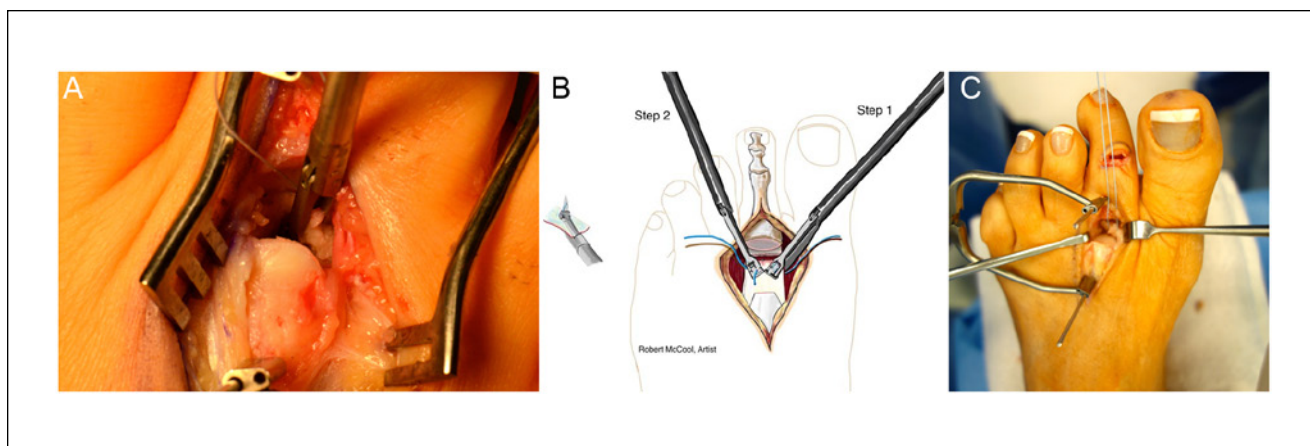


Figure 9. (A) The first pass with the mini Scorpion DX (Arthrex, Naples, FL) through the plantar plate. (B) The same fiberwire suture is reloaded in order to pass through the plantar plate a second time in horizontal mattress fashion. (C) Both suture limbs are securely placed within the plantar plate.

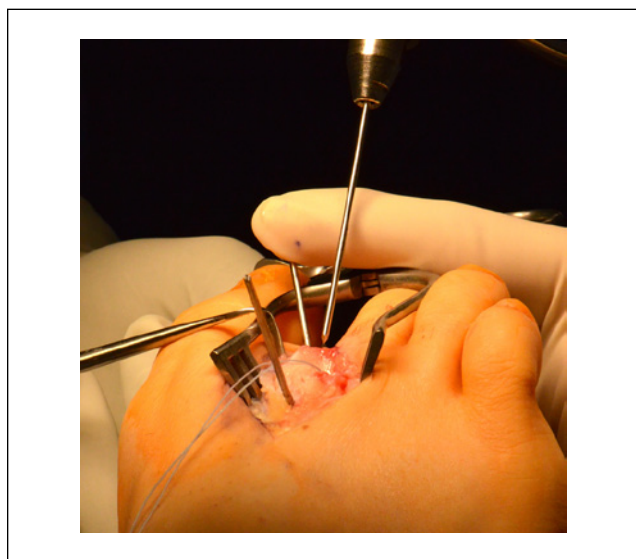


Figure 10. Two drill holes are made in the proximal phalanx for passage of the sutures within the plantar plate.

deformity through the MTP joint may necessitate an extensor tendon Z-lengthening procedure. Typically, Kirchner wire fixation across the MTP joint is not necessary following plantar plate repair (Figure 15). The wound is closed with an absorbable 4-0 monofilament suture in the skin only.

16. A sterile compressive dressing with flexible self-adhesive wrap and postoperative shoe are placed. The operative toe is typically taped in slight plantarflexion to avoid inadvertent dorsiflexion and stress of the plantar plate repair.

Postoperative Protocol

At 0-2 weeks, the postoperative dressing remains in place for 10-14 days. Heel weight-bearing is allowed in a postoperative shoe or short walking boot immediately after surgery. The patient is given crutches to use as desired.

At 2-6 weeks, at the first postoperative visit a wound check and radiographs are obtained. A compressive dressing is applied and the toe is taped into slight plantarflexion as described above. Weight-bearing remains on the heel for the first 6 weeks.

At 6-10 weeks, WBAT in postoperative shoe or walking boot begins at 6 weeks. If a pin was placed for a hammer toe correction, it is removed at this time. The patient now begins active and passive range of motion at the MTP joint. Over the ensuing weeks, as the patient's edema and pain subside, the patient transitions back into an athletic or supportive shoe.

At 10 weeks+, the patient advances activities as tolerated. X-rays are obtained at 12 weeks. Physical therapy is not routinely used unless the patient has difficulty returning to activity due to toe stiffness or swelling.

Complications

Observed complications with this technique include wound infection, hypersensitivity, hematoma formation and healing problems that relate to all foot and ankle surgeries. Other specific possible complications include damage to the extensor and/or flexor tendons as well as articular surface intraoperatively. Failure of the plantar plate repair requiring either a revision repair or a salvage procedure with a flexor to extensor tendon transfer may also occur.

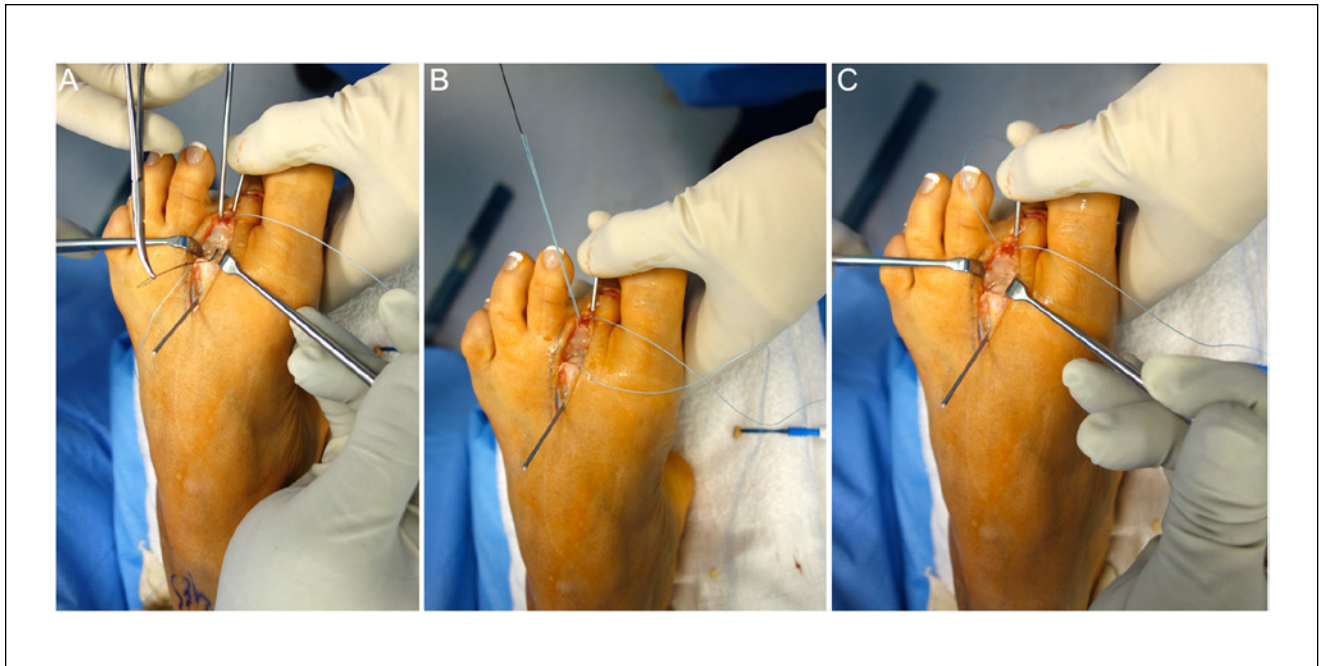


Figure 11. A micro suture passer is used to retrieve the plantar plate sutures through the bone tunnels within the proximal phalanx.

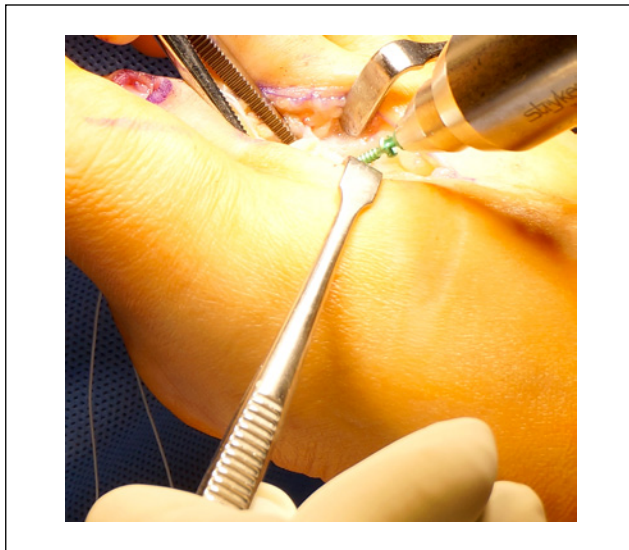


Figure 12. The Weil osteotomy is reduced into its definitive position and secured with a QuickFix screw (Arthrex, Naples, FL)

Finally, nonunion of the Weil osteotomy, although rare, is another possible complication. Reports of painful hardware, metatarsalgia, postoperative MTP joint stiffness, and floating toe have all been described.^{1,17,20} Patients are counseled preoperatively on MTP stiffness, residual toe deformity, and the possibility of a floating toe as well as realistic expectations following lesser toe corrective procedures.

Discussion

Few studies exist describing the results of direct plantar plate repair in combination with a Weil shortening osteotomy. Weil et al published their results on a group of 15 feet (13 patients) with average follow-up of 22.5 months (range, 13 to 32) with 77% of patients (80% of cases) described as being “satisfied” or “very satisfied” with the procedure. Average reported improvement in pain was 71.9% in this series. In all, 80% would recommend the surgery to a patient with the same problem. The same percentage would undergo the procedure again if they would have the same outcome. They also found a statistically significant reduction in visual analog pain score from an average of 7.3 preoperatively to 1.7 postoperatively. No recurrence of MTP subluxation or floating toes was noted at final follow-up.²⁰

Nery et al reported on 40 plantar plates (22 patients) with average follow-up of 17 months after repair using the same approach. In their article, the second MTP joint was the most commonly involved joint (63%) which we have also observed. The medially deviated toe was noted to be the most common deformity. The preoperative pain score was 8 points on average with a reduction to 1 point postoperatively. They did not find an association between anatomic grade of lesion and pain on a 10-point VAS scale. However they did note the highest AOFAS scores in patients with grade 1 and grade 2 tears with postoperative scores of 95 and 96, respectively.¹⁶

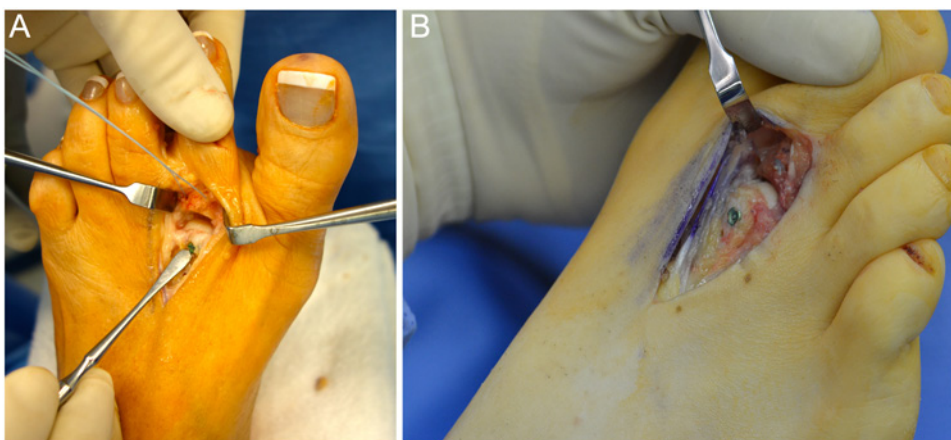


Figure 13. (A) The second MTP joint is held reduced by an assistant while the sutures are tied over the proximal phalanx. (B) Intraoperative view of the joint after Weil osteotomy and plantar plate repair.



Figure 14. (A) Intraoperative view of the foot after all procedures have been performed. Note the clinical resolution of the patient's medial drift. A hammertoe correction had also been performed. (B) Postoperative radiograph demonstrating reduction and decompression of the joint with excellent alignment of the toe.

Gregg et al have also reported on 35 plantar plate repairs (23 feet) treated with a technique similar to what we have described with promising results. All 23 patients reported pain improvement after surgery but 6 patients reported not being satisfied with the procedure. Thirteen of the 23 patients reported no restrictions of activities, 6 had occasional limitations, and 4 reported intermittent limitations.⁶

Summary

The direct plantar plate repair with Weil osteotomy technique is effective as a primary procedure for patients with refractory MTP joint pain and instability due to plantar plate pathology. To date, reported results of plantar plate repair from a dorsal approach with a Weil osteotomy are encouraging. This technique directly addresses the pathology within

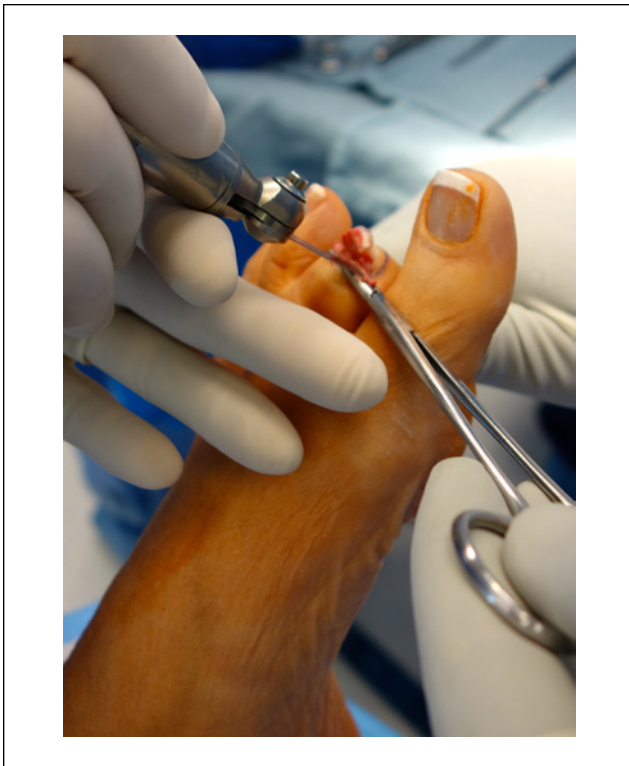


Figure 15. Intraoperatively, adjunct procedures for hammertoe deformity such as the proximal interphalangeal joint resection arthroplasty seen here may be necessary.

the plantar plate rather than relying on indirect reduction of the MTP joint with osteotomy or tendon transfer techniques. Late salvage with a flexor to extensor tendon transfer remains possible should instability, recurrent deformity, or dislocation be noted. Although further study is necessary to demonstrate operative efficacy over the long term,^{6,20} this plantar plate repair technique is recommended to help correct sagittal and transverse plane deformity.

Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: Troy S. Watson, MD, does receive royalties from Arthrex (Naples, FL) the manufacturer of the implants used in this article.

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