INTRODUCTION
The Weil osteotomy is an established and effective osteotomy that is used for both the treatment of lesser metatarsalgia, and to aid in the reconstruction of lesser metatarsophalangeal joint (MPJ) subluxation or dislocation. The Weil osteotomy is particularly indicated in cases of relatively long or plantarflexed metatarsals. Additionally, the procedure is useful in managing cross-over and subluxed or dislocated hammertoe and can be used in a translation fashion to realign the MPJ. The procedure has been popularized due to its simple technique, ability for stable fixation, excellent union rates, and predictable results (1). More recently, this osteotomy has been used in conjunction with repair of the plantar plate. Postoperative complications after a Weil osteotomy can be minimized with appropriate surgical technique (2). The authors will demonstrate that the Weil osteotomy, when used in conjunction with repair of the plantar plate has manageable side effects and allows for excellent reproducible results.

BACKGROUND
The pathomechanics of the plantar plate degeneration and/or rupture involve increased plantar plate pressure due to hallux valgus, first ray insufficiency, hammertoe deformity, elongated lesser metatarsal, and gastrocnemius equinus. One or a combination of these deformities can lead to increased load at the lesser metatarsal head, particularly at the second metatarsal due to its increased length in the typical foot (2). This increased load leads to joint effusion and increased stress on the plantar plate, thus leading to degeneration or rupture. Other cases involve repetitive or acute trauma from an injury or increase in activity (3).

Clinically, patients with plantar plate pathology present with dorsiflexion or dorsal dislocation at the MPJ, often with an accompanying hammered digit. Pain can often be localized to the distal-planter aspect of the MPJ. Some cases present with additional medial or lateral deviation of the proximal phalanx due to more medial or lateral degeneration of the plate (Figure 1).
translated for easy visualization of the plantar plate, thus allowing for a direct repair technique. Numerous techniques have been published that involve direct repair of the plantar plate without the Weil osteotomy including the Arthrex Complete Plantar Plate Repair System and Smith & Nephew HAT-Trick Lesser Toe Repair System. Recently, the plantar plate has been implicated as an important stabilizer of the MPJ. In the past, some procedures attempted the joint repair without direct plantar plate repair. These procedures involved stabilizing the MPJ with a Kirschner wire (K-wire) in an attempt to allow fibrosis to occur and thereby stabilize the joint. This technique typically resulted in a stiff digit and often led to a recurrent hammertoe deformity. Plantar plate repair using a direct plantar approach has been performed in the past, however numerous complications including painful scarring and prolonged immobilization have caused this technique to fall out of favor.

Some proponents of direct plantar plate repair techniques argue that the Weil osteotomy is not necessary due to its relative complications. The osteotomy is associated with various complications including floating toe (36%), recurrence (12.5%), and transfer metatarsalgia (7%) (5). Other complications associated with the Weil include delayed union, non-union, and malunion, which account for 3% of cases overall and are most often associated with significant comorbidities (5). The complication of floating toe is increased when concurrent proximal interphalangeal joint (PIPJ) arthrodesis is performed.

In a study by Migues et al, floating toe occurred 15% of the time without concurrent PIPJ arthroplasty and increased to 50% when the Weil osteotomy was performed with a concurrent PIPJ arthroplasty (7). Floating toe can also be prevented by avoiding plantarflexion of the metatarsal head by ensuring the osteotomy is parallel to the weight-bearing surface, or by using a wafer cut method with parallel osteotomies to achieve more shortening from the osteotomy with minimal capital fragment proximal-planter translation and therefore plantarflexion of the metatarsal head (5). It should also be noted that while floating toe is a common complication associated with the Weil osteotomy, only a fraction of patients with this complication state that they are unhappy with the results (10% in 1 study) (6). There is an inverse relationship noted between recurrence of symptoms in the second digit Weil and simultaneous first ray procedures, indicating a potential need for correction of asymptomatic hallux valgus in the presence of subluxed second MPJ (8). Transfer metatarsalgia has been noted to be a result of excessive shortening. In a retrospective review of the Weil metatarsal osteotomy, transfer metatarsalgia was reduced to 1.1% by simply determining the amount of shortening necessary preoperatively using anterior-posterior radiographs to ensure proper metatarsal parabola (9).

**TECHNIQUE DESCRIPTION**

A longitudinal skin incision is made over the dorsal aspect of the involved digit, from just proximal to the MPJ and extending distal to the PIPJ. Following anatomic dissection, sharp or blunt dissection is carried down to the deep fascia where any crossing vessels should be carefully ligated and divided. A transverse extensor tendon tenotomy is performed at the PIPJ and the tendon is reflected proximally, and a medial and lateral capsulotomy is performed allowing for exposure of the MPJ.

The double cut osteotomy can be performed using 2 blades on the same saw or by making two separate saw cuts. If the surgeon wishes to perform the joystick method for fixation, a K-wire is inserted into the capital fragment prior to the osteotomy. If 2 separate cuts are performed for the double cut osteotomy, the first cut is made at the metatarsal head, parallel to the longitudinal axis of the bone. The capital fragment is then retracted plantarly using a thin osteotome in preparation for the double cut osteotomy. The second cut is oriented slightly distal-dorsal to proximal-plantar, creating a thin wedge-like fragment allowing for dorsiflexion of the capital fragment upon fixation. At this time the wedge-like fragment is removed and the capital fragment is ready for fixation.

Mobilization and fixation of the capital fragment using the joystick technique can now be performed. The joystick method uses the K-wire driven into the capital fragment, prior to osteotomy. This can be used to aid in appropriate positioning of the capital fragment in both the transverse (medial and lateral translocation) or longitudinal (lengthening or shortening) planes. This also aids in compression at the osteotomy site during temporary fixation with a vertical K-wire. Two screws can then be used for fixation of the capital fragment.

Exposure of the MPJ space is excellent and allows for good exposure of the plantar plate. The plantar plate can be carefully inspected and repaired primarily using 2-0 Ethibond suture. Additional procedures can then be performed including an PIPJ arthrodesis. The extensor tendon can be lengthened as needed and should be repaired distally. The subcutaneous and skin layers are then closed.

**CASES**

Three cases are presented, which highlight the double cut or wafer cut technique, along with the joystick technique and adequate visualization for a direct plantar plate repair. These techniques can be used to aid in better control of osseous position and fixation and help reduce postoperative complications.
Case 1.
An illustration of the double cut osteotomy is shown in Figures 2-8.

Figure 2. Clinical presentation of a hammer toe with plantar plate degeneration with cross over second digit.

Figure 3. Radiograph of same patient showing medial dislocation of the second metatarsophalangeal joint.

Figure 4. Saw placement for the Weil osteotomy after joint exposure.

Figure 5. Retraction of the capital fragment in preparation for a double cut osteotomy with an osteotome.
Case 2.
An illustration of the joystick method with K-wire is shown in Figures 9-15.
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Figure 10. Dissection to the metatarsophalangeal joint with Kirschner wire used for the joystick method. Insertion into the capital fragment prior to the osteotomy.

Figure 11. Saw placement for osteotomy with Kirschner wire in place.

Figure 12. Medial translation of the capital fragment with Kirschner wire.

Figure 13. Kirschner wire used for compression with temporary fixation in place.
Case 3.
Illustration of excellent plantar plate exposure for direct repair after a double cut Weil osteotomy is shown in Figures 16-19.

Figure 14. Screw fixation with two screws.

Figure 15. Preoperative and postoperative radiographs with congruent second metatarsophalangeal joint. Note that a second proximal interphalangeal joint arthrodesis along with a first metatarsophalangeal joint arthrodesis were also performed.

Figure 16. Excellent exposure of the plantar plate is achieved after the double cut Weil osteotomy.

Figure 17. After adequate exposure, the plantar plate can be carefully inspected and primarily repaired or tightened as needed.
DISCUSSION

The authors believe that the complications previously mentioned are of little significance if managed appropriately and intraoperatively. Additionally, it is believed that excellent results can be obtained by combining a Weil osteotomy with direct plantar plate repair. In a 2007 study by Gregg et al, 95% of patients with concomitant plantar plate repair and a Weil osteotomy demonstrated no or only mild pain postoperatively (10). In 2011, Weil and colleagues demonstrated that combined plantar plate repair and a Weil osteotomy reduced the visual analog pain scale scores from 7.3 preoperatively to 1.7 postoperatively (11).

From a review of the literature and the authors’ personal experience, it can be concluded that direct plantar plate repair combined with a Weil osteotomy gives patients the best result in terms of treatment of the rupture and correction of the osseous deformity.

REFERENCES

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