



Contents lists available at ScienceDirect

The Journal of Foot & Ankle Surgery

journal homepage: www.jfas.org

Tips Quips, and Pearls

Editor's Note: Unlike our typical Tips, Quips and Pearls article, the description of a clinical case is embedded in this technical report; hence, the level of clinical evidence is also reported.

An Innovative Method for Plantar Plate Repair: Technique Guide and Case Report

J. Randolph Clements, DPM, FACFAS¹, Ajay K. Ghai, DPM, AACFAS²

¹ Associate Professor, Carilion Clinic, Virginia Tech School of Medicine / Institute of Orthopaedics and Neurosciences, Roanoke, VA

² Foot and Ankle Surgery Resident PGY-3, Carilion Clinic, Virginia Tech School of Medicine Podiatry Residency Program, Roanoke, VA



ARTICLE INFO

Level of Clinical Evidence: 4

Keywords:

metatarsalgia
metatarsophalangeal joint malalignment
plantar plate
predislocation syndrome
second metatarsophalangeal joint instability

ABSTRACT

Disruption of the plantar plate is a common cause of forefoot pain, metatarsalgia, and metatarsophalangeal joint malalignment. Although surgical repair of the plantar plate has improved, there has been no consensus on the clinical superiority of any single technique, or combination of techniques, described in the literature to date. In this publication, we report a case of plantar plate injury treated with an innovative new technique with 20-month follow-up.

© 2018 by the American College of Foot and Ankle Surgeons. All rights reserved.

The plantar plate complex provides cushion to the metatarsal head and serves as an important stabilizer to the metatarsophalangeal joint (MTPJ). Plantar plate injury is a common cause of forefoot pain, metatarsalgia, and MTPJ malalignment. This malalignment can be a subtle subluxation or complete dislocation of the MTPJ. The precise etiology of MTPJ instability is not known. Most MTPJ instability occurs within the second ray, and several possible factors have been described to be associated with plantar plate tears at this location, including hallux rigidus, hypermobility, and hallux valgus (1,2). Hypermobility of the first ray can result in lateral load-bearing transfer to the second MTPJ, whereas hallux abductovalgus deformity can result in crowding of the second toe, leading to sagittal and transverse plane deformity, subluxation, and/or dislocation (2). Additional reported causes of plantar plate disruption include trauma; inflammatory arthritis; synovitis; an elongated metatarsal, which produces increased pressure on the plantar structures, namely the plantar plate complex; and muscle imbalance owing to the pathology associated with lumbrical and interosseous muscles (2,3).

Surgical plate repair of the plantar plate has evolved over the past decade, as surgeons have developed greater understanding of the MTPJ, and although multiple surgical repair techniques have

been developed, no consensus has been reached on which single or combined technique is clinically superior (3–9). In this report, we describe a simple and novel technique to repair the plantar plate complex.

Technique and Case Report

To aid description of the technique, its use in an adult female will be described. The patient was a 77-year-old female who presented to the outpatient orthopedic foot and ankle department with a chief complaint of long-standing painful second-digit hammertoe of the right foot. She stated that her pain was 6/10, using a 10 point grading system with 0 being no pain and 10 being the worst pain she has ever felt, plantarily and dorsally localized to the second digit. The pain was sharp and worse with constrictive shoe gear and ambulation. The patient had previously exhausted conservative treatments, including bracing, taping, padding, nonsteroidal antiinflammatory medications, and shoe gear modification, without relief. She reported that the pain interfered with her activities of daily living and prevented her from pursuing ambulation for exercise. Medical history included gastroesophageal reflux disease, hypothyroidism, and contracture of palmar fascia. Medications included levothyroxine 75 μ g per os (PO) daily, simethicone 250 mg PO daily, 1000 mg fish oil supplement PO daily, omeprazole 20 mg PO daily, and aspirin 81 mg PO daily. The patient had no known drug allergies. No pertinent family or social medical history was present. The postoperative treatment protocol and long-term follow-up results are presented later in the article.

Financial Disclosure: None reported.

Conflict of Interest: None reported.

Address correspondence to: Ajay K. Ghai, DPM, AACFAS, Carilion Clinic/VTSOM Podiatry Residency Program, 1906 Belleview Avenue SE, Medical Education Building, Room 232, Roanoke, VA 24014

E-mail address: ajay.k.ghai@gmail.com (A.K. Ghai).



Fig. 1. Three-view weightbearing preoperative radiographs taken 1 month before surgery.

Physical Examination

Physical examination revealed a semirigid second-digit hammertoe contracture of the right foot, with extension at the MTPJ and flexion at the proximal interphalangeal joint (PIPJ). A positive Lachman test with elicited pain was present at the second MTPJ. Tenderness to palpation was present dorsally over the PIPJ. Hyperkeratotic tissue was present over the second-digit PIPJ and at the distal digit. Ankle and first MTPJ range of motion were within normal limits. Manual muscle testing revealed no gross deficiencies. On weightbearing, the patient had mostly maintained medial longitudinal arch, and heels were in slight valgus. The neurovascular examination was within normal limits.

Imaging Studies

Three-view weightbearing radiographs of the right foot (Fig. 1) were taken 1 month before surgery, revealing an intermetatarsal

angle of 11° , a hallux abductus angle of 18° , a 5° medial deviation of the second digit, a 35° dorsal deviation of the proximal phalanx relative to the second metatarsal, and a 20° flexion contracture at the PIPJ.

Surgical Technique

This technique is innovative in its method of suture passing, and it is very similar to a technique pioneered by Coughlin et al (10) and Nery et al (11), who mention using a name brand system to pass the suture (which can be expensive). Alternatively, a small curved suture needle can be used. We found the small curved suture needle to be inexpensive but difficult to use, given the limited space present in the MTPJ. The following technique uses an innovative yet simple and relatively inexpensive (in terms of crude material cost) method for plantar plate repair. The images in this technique guide are from a patient treated at a later date by using the same method with hammertoe correction;

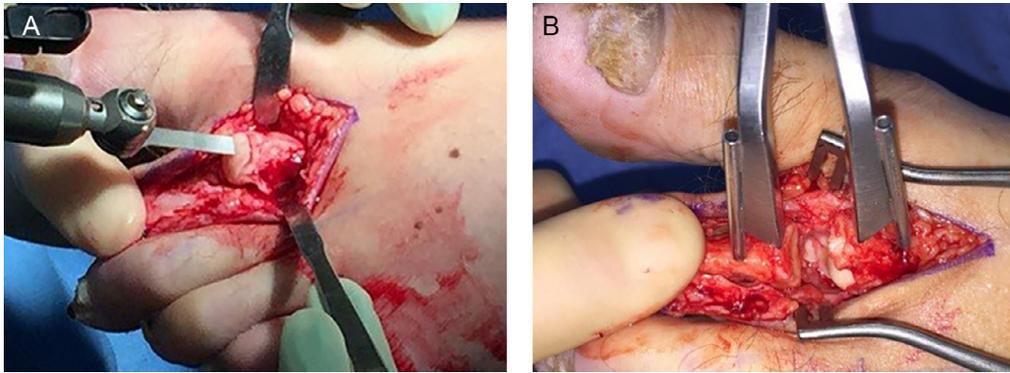


Fig. 2. (A) After exposure of second metatarsophalangeal joint, Hohman retractors are placed below second metatarsal head in preparation for the metatarsal osteotomy. This is done purely for increasing surgical field of view. A rongeur and/or rasp is used to roughen the surface of plantar proximal phalanx base to increase adherence of the plantar plate after repair. (B) Two K-wires are placed, and a distractor is used to open up the joint space to visualize the disrupted plantar plate.

however, we were unable to contact the patient for a follow-up after initial healing.

The procedure is performed with patient in a supine position. Intravenous anesthesia is administered, and local anesthetic is injected into the surgical field. After anesthesia has been administered, the foot is prepped and draped by using standard aseptic technique. A pneumatic ankle or calf tourniquet is used, and after elevation and exsanguination, the tourniquet is inflated to 250 mmHg. A 6- to 8-cm curvilinear incision is drawn over the affected MTPJ. This incision extends from diaphysis of the MTPJ to the PIPJ. A gentle curve is placed just proximal to the MTPJ in an attempt to reduce the tendency for dorsal scar contraction. A no. 15 blade is used to incise the skin, and tenotomy scissors are used to dissect down to the MTPJ. A linear capsulotomy is made, and the metatarsal head is exposed. The metatarsal head is mobilized by using a McGlamry elevator. Two small Hohman retractors are placed on the medial and lateral aspects of the metatarsal head. These are used to retract the capsule and other soft tissue structures. A dorsal distal to proximal plantar metatarsal osteotomy is then made in the metatarsal head (Fig. 2A). The metatarsal head is then translated proximally to improve access to the plantar plate. Next, the proximal phalangeal base is dissected, and any soft tissue attachments are freed away from the base of the proximal phalanx to allow access to the plantar aspect of

the proximal phalangeal base. Next, a small rongeur and a bone rasp are used to remove any remaining plantar plate attachment and decorticate the plantar aspect of the proximal phalangeal base. To improve adherence of the plantar plate to the proximal phalangeal base, the bone is decorticated just distal to the articular surface. Two small K-wires are then placed from dorsal to plantar on the diaphysis of the proximal phalanx and distal metatarsal. A joint distractor is then placed over these wires to increase visibility and access to the pathology plantar to the MTPJ (Fig. 2B).

Next, the torn plantar plate is grasped with a small forceps. A large braided nonabsorbable suture is placed on a Keith needle, which is then passed dorsal to plantar through the proximal aspect of the plantar plate and through the skin of the plantar aspect of the foot (Fig. 3A,B). The Keith needle is removed and placed on the opposite end of the non-absorbable stitch. The suture is then passed in an identical way from dorsal to plantar, approximately 1 cm medial to the initial pass (Fig. 3C). This creates a horizontal mattress within the plantar plate, with both suture threads exiting the skin on the plantar aspect of the foot. Then, an 18-gauge needle or a 0.45-inch K-wire is bent to form a small hook (Fig. 4A). This is used to retrieve the suture thread from in between the plantar plate and the flexor digitorum longus tendon. Once the 2 suture threads have been identified, they are pulled dorsally from beneath the

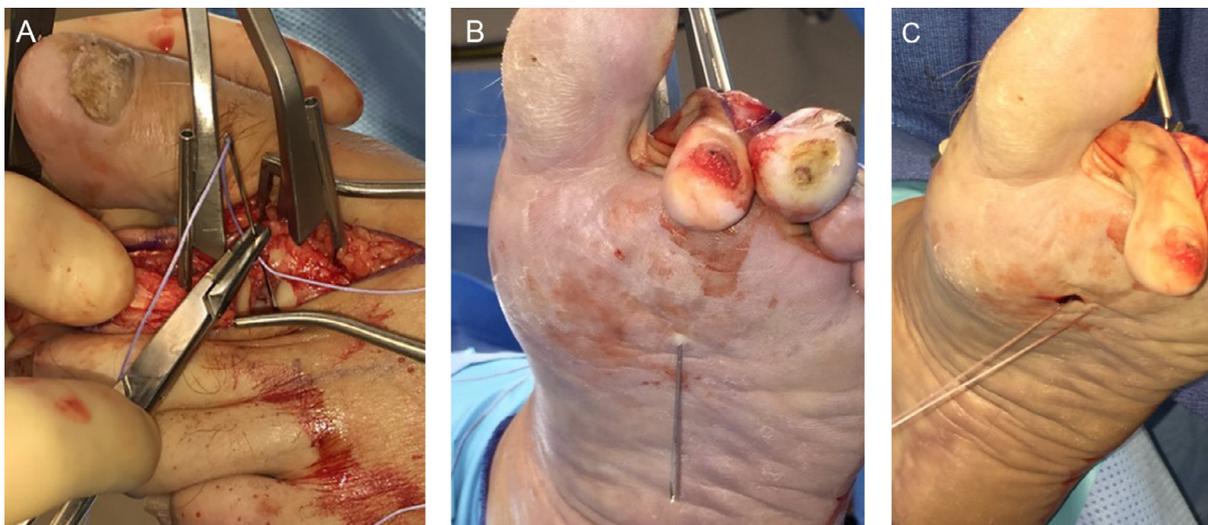


Fig. 3. (A,B) A Keith needle is passed dorsal to plantar through the plantar plate and through the skin of the plantar aspect of the foot. (C) The suture is pulled through with the needle, and then the process is repeated, leaving 2 suture tails out of the plantar aspect of the foot.

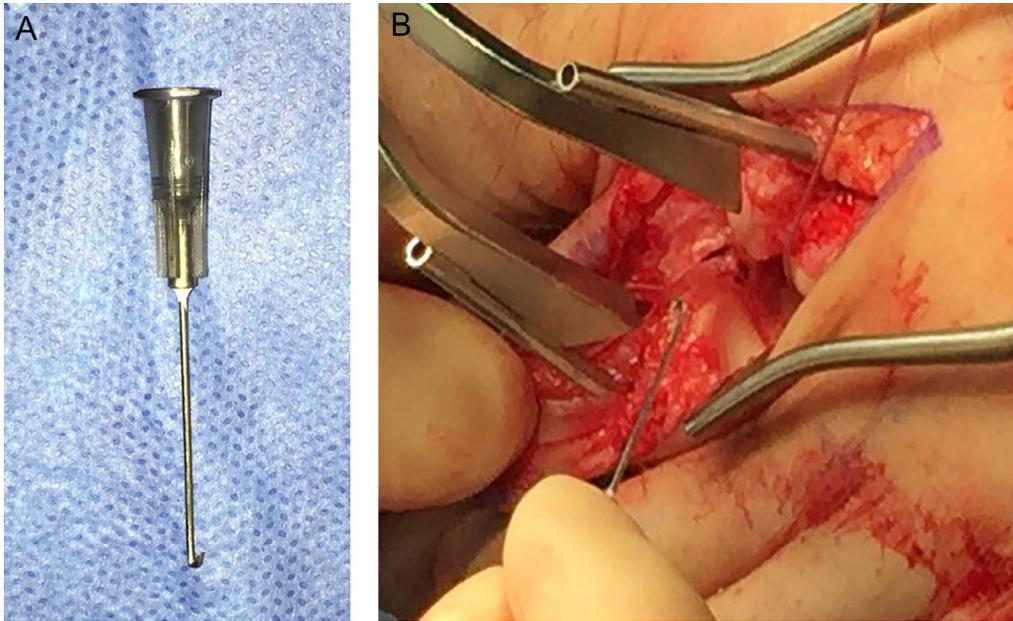


Fig. 4. (A) An 18-gauge needle is bent at the distal end to form a small hook. (B) This is used to retrieve the suture from between the plantar plate and flexor digitorum longus tendon. The surgeon should now have 1 horizontal mattress suture within the plantar plate and both suture tails within the dorsal aspect of the surgical field.

plantar plate (Fig. 4B). If the technique is performed correctly, the surgeon should now have 1 horizontal mattress suture within the plantar plate and both suture tails within the dorsal aspect of the surgical field.

Subsequently, the proximal phalanx is held with an Allis clamp, and a 2-mm drill bit is used to drill 2 crossing pilot holes in the proximal phalangeal base. These 2 holes are drilled from dorsal to plantar at a 45° angle toward the medial and lateral flare of the proximal phalanx in the frontal plane (Fig. 5A). Any rotational deformity of the phalanx should be corrected at this time. The frontal plane deformity can be corrected and maintained with the Allis clamp before drilling the pilot holes. The previously used Keith needle is now placed, with the eyelet (proximal) end first, through the pilot holes from dorsal to plantar. The suture is then placed through the eyelet, and the needle is shuttled through the drill hole, taking the suture from plantar to dorsal. This is repeated for the second suture tail.

Now, the metatarsal head is reduced to its native position and stabilized with a 2- or 2.7-mm screw. If the metatarsal protrusion distance supports shortening of the metatarsal, the metatarsal head can be

placed in the desired shortened position and stabilized with the fixation described previously. At this point, the toe is plantarflexed, and the plantar plate is approximated to the proximal phalangeal base via tensioning the sutures on the dorsal aspect of the phalanx. Once the toe has been restored to the correct position under the optimal tension, the suture is tied by hand, leaving a knot on the dorsal aspect of the phalanx (Fig. 5B). The suture is then cut, leaving no tails. If additional correction of a digital deformity is necessary after restoration of the plantar plate, it may be performed at this time (Fig. 6A–C). An artist rendering of the plantar plate repair technique is shown in Fig. 7.

Postoperative Protocol

In general, patients are permitted to bear weight in a postoperative rigid orthopedic shoe or orthopedic walking boot immediately postoperatively. The sutures are removed at approximately 10 to 14 days. At this time, gentle plantarflexory exercises and taping are encouraged, but



Fig. 5. (A) After securing the proximal phalanx with an Allis clamp, a 2-mm drill bit is used to drill 2 pilot holes parallel to each other at a 45° intersecting angle in the frontal plane into the proximal phalanx base. (B) The previously used Keith needle is then placed, with eyelet end first, through the pilot holes from dorsal to plantar. The suture is then placed through the eyelet, and the needle is shuttled through the drill hole, taking the suture from plantar to dorsal. This is repeated for the second suture tail. The metatarsal head is then reduced to its anatomic position and stabilized with a 2.0- or 2.7-mm screw. The toe is plantarflexed, and the plantar plate is approximated to the proximal phalangeal base via tensioning the sutures on the dorsal aspect of the phalanx. Once the toe has been restored to the correct position under the optimal tension, the suture is tied by hand, leaving a knot on the dorsal aspect of the phalanx.

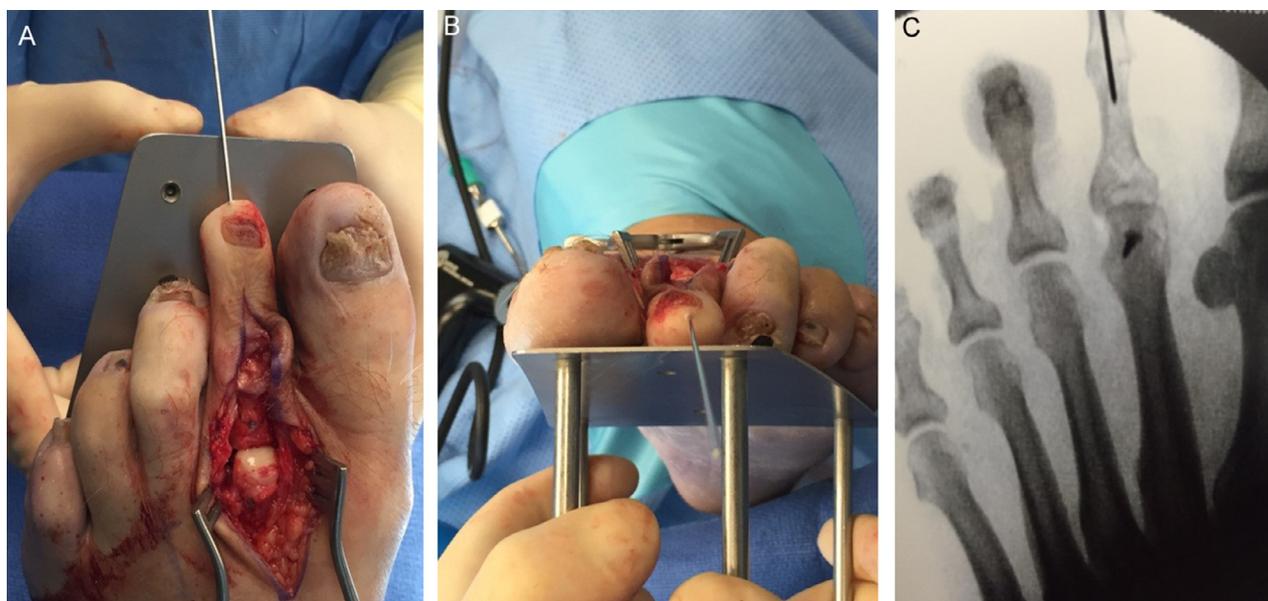


Fig. 6. (A–C) If additional digital correction is needed, such as proximal interphalangeal joint arthroplasty in this case, it may be performed at that time or just before the suture is tied. Final correction with proximal interphalangeal joint arthroplasty is shown above.

passive dorsiflexion should be restricted for 6 weeks. The patients are allowed to transition out of protective orthopedic shoe gear at 6 weeks.

The patient in this case study had a 1-week follow-up to check the incision, and sutures were removed at 2 weeks, without any complications. In between the 2- and 4-week follow-up, the patient stated that she struck her foot against a piece of furniture and the K-wire cap came loose. Four weeks after surgery, weightbearing radiographs were obtained before pin removal (Fig. 8). These radiographs revealed maintained correction and alignment, but a portion of the K-wire was now crossing the MTPJ, likely because of the accidental trauma. The patient had the K-wire removed and was transitioned to a supportive athletic shoe at 6 weeks. The patient had a 12-week follow-up and reported satisfaction with her second toe of the right foot. The patient was then instructed to stop taping and to follow up as needed.

Follow-Up Results

The patient in this study went from 6/10 foot pain to now being free of foot pain 20 months after surgery and was very satisfied with

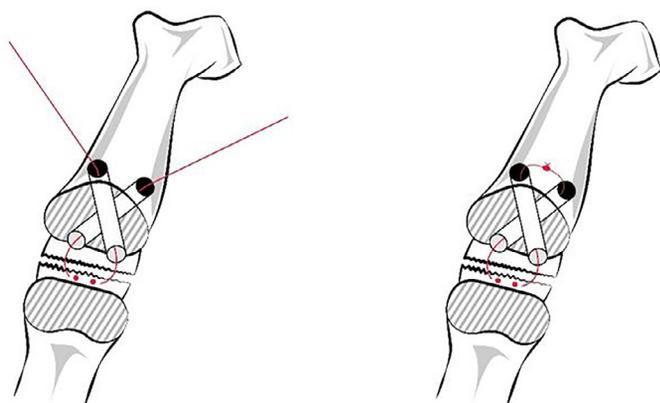


Fig. 7. Artist rendering of the plantar plate repair technique (drawn by Y.X. Shown with permission).

the outcome. Her only complaint was nonpainful stiffness at the second MTPJ, with decreased dorsiflexion. A 10-point verbal rating scale was converted from a previously validated 20-question 100-point foot-and-ankle visual analogue scale (12). This was owing to difficulty in completing the visual analogue scale. The questionnaire consisted of 4 questions on pain, 5 on other complaints, and 11 on function. The patient's postoperative score was 88 out of 100, with a higher score indicating a better outcome. A preoperative verbal rating scale for comparison was not performed owing to the retrospective nature of this case study. The patient stated that she would undergo the procedure again.

Discussion

Plantar plate instability and second metatarsal pathology have been well documented within the past decade, and surgeons have gained a better understanding and appreciation for restoring this anatomy when treating metatarsal phalangeal joint instability and pain. Commonly used techniques to repair the plantar plate include individual dorsal and plantar approaches, combined approaches, metatarsal shortening osteotomy, and flexor digitorum longus tendon transfer (3–9). However, as mentioned previously, there is no clear consensus on the most superior technique. New techniques are constantly evolving (13). The dorsal approach prevents potential plantar scarring and prolonged non-weightbearing, provides the ability to shorten the metatarsal, and minimizes incisions if a hammertoe deformity needs to be corrected concurrently (14). The plantar approach provides a more direct approach and visualization to plantar plate repair but has the inherent drawbacks listed earlier (6). Tendon transfers weaken the ability to flex the lesser toes, decreasing the ability to grip the ground and provide thrust during toe-off (15).

This novel technique avoids a plantar incision and therefore the potential for painful scarring and the need to be non-weightbearing. This procedure negates the need for tendon transfers and simplifies the dorsal approach for direct plantar plate repair. However, the technique does have minor drawbacks, and in our opinion, it is most useful for transverse ruptures in plantar plate repairs. Ancillary modifications may be needed for longitudinal tears. We are aware of the theoretical complication of nonabsorbable suture eroding through bone over time, resulting in possible



Fig. 8. Three-view weightbearing postoperative radiographs taken 1 month after surgery.

fracture; however, this complication has not been observed. The patient in this study had a promising 20-month outcome, with complete pain relief and return to full physical activity. A few additional patients have reached the 6-month follow-up, and no major complications have been noted.

In addition to the procedures mentioned previously, several systems have been designed to simplify plantar plate reconstruction. However, we have found these systems and instrumentation to be frustrating and not uniformly applicable in all cases. In addition, these systems are costly, with prices ranging from hundreds to thousands of dollars. In comparison, the technique described in this article provides a simple, effective, and inexpensive (in terms of crude material cost) means of surgical repair while avoiding a plantar incision.

In conclusion, this innovative technique is appropriate for most plantar plate ruptures leading to biomechanical dysfunction and pain,

but further research must be carried out to determine long-term outcomes and applicability of this procedure versus its alternatives.

Acknowledgments

The authors thank Ioannis Minos Xilikakis for assisting with artist rendering of procedure.

References

1. Coughlin MJ. Crossover second toe deformity. *Foot Ankle* 1987;8:29–39.
2. Sanhudo JA, Ellera Gomes JL. Pull-out technique for plantar plate repair of the metatarsophalangeal joint. *Foot Ankle Clin N Am* 2014;17:417–424.
3. Prissel MA, Hyer CF, Donovan JK, Quiso AL. Plantar plate repair via a direct plantar approach: an outcomes analysis. *J Foot Ankle Surg* 2017;56:434–439.

4. McAlister JE, Hyer CF. The direct plantar plate repair technique. *Foot Ankle Spec* 2013;6:446–451.
5. Camasta CA. Plantar plate repair of the second metatarsophalangeal joint. In: DE McGlamry, ed. *McGlamry's Comprehensive Textbook of Foot and Ankle Surgery*, 4th ed, Vol. 1, Lippincott Williams & Wilkins, Philadelphia, 2013,187–201.
6. Blitz NM, Ford LA, Christensen JC. Plantar plate repair of the second metatarsophalangeal joint: technique and tips. *J Foot Ankle Surg* 2004;43:266–270.
7. Bogy LT, Vranes R, Goforth WP, Caporusso JM. Correction of overlapping second toe deformity: long-term results including a 7-year follow-up. *J Foot Surg* 1992;31:319–323.
8. Mendicino RW, Statler TK, Saltrick KR, Catanzariti AR. Predislocation syndrome: a review and retrospective analysis of e0ight patients. *J Foot Ankle Surg* 2001;40:214–224.
9. Yu GV, Judge MS, Hudson JR, Seidelmann FE. Predislocation syndrome. Progressive subluxation/dislocation of the lesser metatarsophalangeal joint. *J Am Podiatr Med Assoc* 2002;92:182–199.
10. Coughlin M, Nery C, Baumfeld D. Second MTP joint instability grading of the deformity and description of surgical repair of capsular insufficiency. *Phys Sportsmed* 2011;39:132–134.
11. Nery C, Coughlin MJ, Baumfeld D, Mann TS. Lesser metatarsophalangeal joint instability: prospective evaluation and repair of plantar plate and capsular insufficiency. *Foot Ankle Int* 2012;33:301–311.
12. Richter M, Zech S, Geerling J, Frink M, Knobloch K, Krettek C. A new foot and ankle outcome score: questionnaire based, subjective, visual-analogue-scale, validated and computerized. *Foot Ankle Surg* 2006;12:191–199.
13. Judge MS, Hild G. A suture-button technique for stabilization of the plantar plate and lesser metatarsophalangeal joint. *J Foot Ankle Surg* 2018;57:645–653.
14. Watson DS, Reid DY, Frerichs TL. Dorsal approach for plantar plate repair with Weil osteotomy: operative technique. *Foot Ankle Int* 2014;35:730–739.
15. Palastanga N, Soames R. *Anatomy and Human Movement: Structure and Function*. 6th ed. Churchill Livingstone, London, United Kingdom; 2012.