Prospective Evaluation of a Multiplanar Correction Technique for Plantar Plate Tears of the Lesser Metatarsophalangeal Joints

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Literature Review and Purpose

Lesser metatarsophalangeal joint (MTPJ) pathology is very common in the foot and ankle. The plantar plate in particular has been extensively studied in the past decade. Originally described in 1986, a "crossover toe" represented an end stage digital deformity of the lesser metatarsophalangeal joint.[1] Recognition of this pathology in earlier stages has been described to help the surgeon identify and treat the patient before complete metatarsophalangeal joint subluxation. The lesser MTPJs are surrounded by multifarious soft tissue structures that involve both dynamic and static forces. The dynamic forces that stabilize the lesser MTPJ are the intrinsic and extrinsic muscles of the foot. However, it is mainly the plantar plate that stabilizes the MTPJ in the sagittal plane.[2]

The development of lesser MTPJ deformity typically occurs from either direct trauma or mechanical overuse. Etiologies of this consist of elongated second metatarsal, a hypermobile first ray, hallux valgus, hallux limitus, and pes planus, all of which result in repetitive trauma to the plantar plate.[3,4] Plantar pain present at the base of the second toe is the most common complaint for plantar plate tears.[5] Patients may feel as if they are "walking on a marble," and the pain is often increased with ambulation and decreased with rest.[6] An unstable MTPJ can be determined during physical examination with a modified Lachman, or "dorsal drawer" test, the "Paper pull-out test," and transverse plane deformity can be observed clinically with medial or lateral deviation of the toe while weight-bearing.[7,8] Various imaging modalities can be used for diagnosing a plantar plate; radiographs, MRI, ultrasound, although arthrogram is the classic gold standard for these injuries.[6,9]

Patients usually seek out treatment once significant pain and deformity are present, which limits the success of conservative treatment options. Different nonsurgical modalities consist of: low-heeled shoes with wide toe box, rocker bottom soles, metatarsal pads, graphite foot plates to stiffen the toe box, hammertoe padding, tapping, Budin splints, and intra-articular corticosteroid injections.[6] Conservative treatment allows for symptomatic relief and decreases the rate of progression of the deformity, but often does not correct the underlying etiology and pathology.[10] Multiple methods and techniques have been published for repairing plantar plate, including: plantar approach, dorsal approach, direct repair, metatarsal osteotomies with or without suture stabilization, among others.[8,10-17] Due to the small anatomy, plantar plate repairs can be very challenging and time consuming, as well as difficult to address both the sagittal and transverse planes. We present a technique that is knotless in repair with a metatarsal osteotomy, providing a strong construct allowing patients to protective weight-bear immediately, providing multiplanar correction, that can improve operation time by presenting ways to quickly navigate the procedure.

The purpose of this study is to prospectively evaluate this plantar plate repair technique that addresses multiple planes of deformity, and examine patient radiographic, functional, and satisfaction outcomes.

Methodology & Hypothesis

18 patients (19 plantar plate tears) were prospectively followed and received a plantar plate repair between February 2016 to March of 2017. Each patient received the described technique with a dorsal approach, knotless plantar plate repair, with correction of multiple planes of deformity. Evaluations were performed before and after surgical treatment with a mean follow up of 13 months (6-20 months), clinical and radiographic parameters were used, including: American College of Foot and Ankle Surgeons (ACFAS) Forefoot Evaluation Scoring Scale, patient satisfaction, and toe purchase.

Procedure

The procedure is performed with a standard dorsal approach to the MTPJ, a linear dorsal capsulotomy, with further release of the medial and lateral capsular attachments. A decompressional metatarsal osteotomy is then performed, and the author prefers to take a wafer osteotomy (or wedge if dorsiflexion is desired) (Fig. 1). This is decided pre-operatively to best restore the metatarsal parabola. Two 1.6mm K wires are then used both for temporary fixation as well as for the joint distraction. Do not advance the distraction wires past the plantar cortex. If it is advanced through the cortex of the metatarsal it snags the plantar plate. The plantar plate is then evaluated, the author will complete the tear at the base of the proximal phalanx. Next, a 2-4mm section is taken off the distal aspect of the plantar plate, up to, or past the tear if appropriate. This section can also be wedged, in order to aid in transverse plane correction.

Figure 1. (a,b) metatarsal wafer osteotomy with parallel cuts, (c) rectangular wafer removed.

Utilizing a suture passer, 3 separate passes with a 2-0 non-absorbable suture are performed in the mobilized plantar plate (Fig. 2). The joint distractor is then removed, distal wire is kept and used as a joystick, while the proximal wire is kept in the metatarsal head for temporary fixation. Use the distal guidewire to help visualize the plantar aspect of the proximal phalanx, as you can maximally plantarflex the toe to visualize exit of K wire pilot holes. Next, drill dorsal to plantar suture holes utilizing a 1.6mm K wire The deformity usually has a dorsal sagittal plane deformity and medial transverse plane deformity. To aid in transverse plane correction, the lateral suture hole is made more distal than the medial (Fig. 2). To further aid in sagittal plane correction, suture holes are made more distal in the proximal phalanx. The suture holes are then over-drilled using a for future placement of absorbable suture anchors. Suture passers are then used to pass the 3 strands sutured to the plantar plate.

After suture is passed through the proximal phalanx dorsally, all temporary K wire fixation is removed. The metatarsal head is brought out the appropriate length and fixation of the surgeon's choice perpendicular to the osteotomy is performed. Intraoperative fluoroscopy is used to confirm correction of metatarsal parabola. The toe is then brought into an overcorrected position, typically plantar flexed and laterally deviated, the suture is then pulled dorsally and proximally towards the metatarsal.

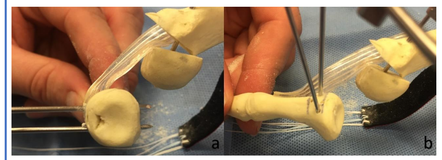

Figure 2. (a) Suture hole placement in proximal phalanx. (b) Wire placement in proximal phalanx can be angled to aid in transverse plane correction.

The sagittal and frontal plane correction can be dialed in at this time pulling the lateral stitches first, then the medial. With slight overcorrection being maintained, the anchors are placed in the suture holes of the proximal phalanx, allowing for multiplanar correction (Fig. 3). The toe is bandaged in an overcorrected position, and patient can ambulate weight-bearing as tolerated in a CAM walker.

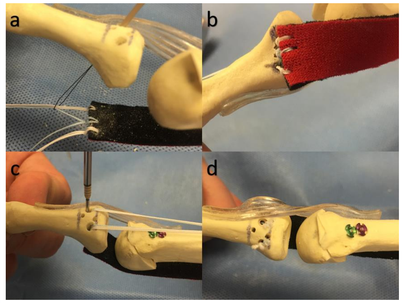

Figure 3. (a) Use suture passer to pull suture from plantar to dorsal aspect of proximal phalanx. (b,c) After metatarsal fixation pull suture proximally to secure multiplanar correction of the plantar plate. (d) Insert anchor under appropriate tension, then cut suture flush for knotless repair.

Results

Figure 4. Pre- and post-operative radiographs of patient receiving 2nd MTPJ plantar plate repair, with a chevron 1st metatarsal osteotomy, and an Akin osteotomy.

	Total Repairs	Pain (30)*	ACFAS (100)	Patients That Liked Appearance	Toe Purchase
Pre-op	19	13.2	35.6	1/18	0
Post-op	19	25.4	86.4	18/18	19

Table 1. Results from data collected pre- and post-operation. Mean averages taken for both pain and ACFAS Forefoot Scores. *Less pain the closer you are to 30.

All patients improved regarding patient satisfaction with appearance, radiographic outcomes, and functional assessment. The mean average ACFAS Forefoot Score improved from 35.6 pre-operatively to 86.4 post-operatively. All 18 patients either "mostly liked", or "very much liked" the cosmetic outcome of their foot. Mean average pain scores also improved from 13.2 to 25.4. Toe purchase was present post-operatively in 11 of the 19 cases.

Discussion

Over recent years, surgical treatment for plantar plate pathology and lesser MTPJ instability has gained attention as there has been multiple methods and techniques published for repair. Most often described in literature are the direct repair and plantar approaches. With a plantar approach, the patient much remain non-weight bearing and often an elongated second metatarsal is not addressed. The metatarsal osteotomy has been shown to have great functional outcomes due to addressing underlying biomechanical pathology. Nery and Colleagues[17] had a similar approach to their plantar plate repair which showed excellent postop AOFAS scores of 95 and 96 in grade 1 and 2 tears. The osteotomy however is not without complications. The authors did report non-unions, painful hardware, joint stiffness and a floating toe syndrome.[17]

Interference screws have also been described in literature with lesser MTPJ pathology with knotless repairs.[11,14] Feldman[14] described the use of interference screws for flexor tendon transfers in 2005. Sung[11] described a dorsal plantar plate ligament repair utilizing a suture tape with an interference screw and one strand of suture tape. They did not include the native plantar plate or address the metatarsal limiting the amount of multiplanar correction.

Plantar plate and pre-dislocation syndrome are mainly sagittal plane deformities and addressed as such. However, patient commonly have a transverse plane component from tight medal capsular structures that causes toes to drift medially. To address this plane, there have been multiple of proposed techniques that include: 1) angling the wafer osteotomy/metatarsal head fixation 2) wedge resection of remaining plantar plate, 3) placement of sutures in the plantar plate 4) location and angulation of suture tunnel in base of proximal phalanx 5) appropriate tensioning prior to interference anchor. Lastly, frontal plane correction can also be achieve base on the placement of suture tensioning.

The plantar plate technique described includes a dorsal approach, metatarsal osteotomy, and a knotless repair of the native plantar plate ligament. Advantages of the knotless repair include: no loosening of the knot over time, tensioning of suture can be maintained and optimized until fixated with the interference anchor, and the decreased risk of prominent knot and scar tissue dorsally. Biomechanically, the metatarsal osteotomy will treat underlying cause of the plantar plate and prevent recurrence. Most importantly, this technique allows the surgeon to address the triplanar deformity associated with plantar plate tears. This technique can help the surgeon with operative time, create a strong construct that permits immediate postoperative weight-bearing in a surgical shoe or boot. The authors have had great success with this technique, however understand that a cohort or comparative study with other techniques would be beneficial. In summary, we believe that this plantar plate technique can be very useful for surgeons to treat patients with multi-planar lesser MTPJ deformities.

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