INTRODUCTION

The term “predislocation syndrome” was first coined in 1995 by Yu and Judge as “an acute, subacute or chronic and exquisitely painful inflammatory condition of the plantar plate of the lesser metatarsophalangeal joints, which if left untreated or mistreated, will result in eventual metatarsophalangeal joint luxation” (1). Plantar plate insufficiency is now a well established pathology that is known to contribute to lesser metatarsophalangeal joint (MPJ) instability, most commonly affecting the second MPJ (2).

Stability of the lesser MPJ is comprised of static and dynamic anatomic restraints. Static stability of the MPJ is provided by the plantar plate and collateral ligaments, while dynamic stability of the MPJ is maintained by the extrinsic and intrinsic musculature (2,3). The plantar plate is the fibrocartilagenous, cup-shaped, intra-articular plantar ligament of the MPJ, which is the termination of the plantar fascia, that resists tensile loads in the sagittal plane and supports compressive forces (3,4). Histologically similar to the meniscus of the knee, the plantar plate is mostly comprised of type 1 collagen, which may be a factor in the poor healing capability of a plantar plate injury (5). Anatomic and biomechanic studies have shown that the plantar plate is the main stabilizing force of the MPJ and the ability of the intrinsic and extrinsic musculature to stabilize the MPJ is largely dependent on the integrity of the plantar plate (2-5). Thus, reconstruction of the plantar plate is key to restoring the stability of the MPJ.

CLINICAL EVALUATION

Patients typically report forefoot pain and swelling, but may present with different symptoms depending on the chronicity of the deformity (3). Patients may report “walking on marbles” that is worse with ambulation and better with rest (3,4). The point of maximal tenderness is usually just distal and plantar to the affected metatarsal head (3). This is the insertion point of the plantar plate onto the base of the proximal phalanx and was described as the rupture zone by Blitz et al (6). Symptoms can be acute, but the majority of cases are chronic in nature (4). In a study by Klein et al, 69% of patients reported pain present for more than 6 months and 93% of patients presented with a gradual onset of pain (7).

A hammertoe or crossover toe can indicate a disruption of the plantar plate, although plantar plate tears can occur without an obvious deformity (7). The affected toe typically exhibits dorsal migration of the proximal phalanx with a medial drift in the transverse plane related to instability of the intrinsic musculature at the joint (2). In chronic cases, there is subsequent subluxation and dislocation of the joint. Klein et al found the presence of a crossover toe to have a 88.9% specificity for plantar plate tears (7).

Many clinical tests have been utilized to aid the diagnosis of a plantar plate tear. The vertical stress test, described by Thompson and Hamilton, evaluates MPJ stability and is positive if there is greater than 2 mm dorsal displacement or 50% joint subluxation (8). Klein et al found a positive vertical stress test to be the most specific (99.8%) of all clinical examination findings, with a positive predictive value of 92.6% (7).

The paper pull-out test, described by Bouche and Heit, is an effective test to evaluate dynamic digital purchase (9). With the patient weightbearing, a strip of paper is placed underneath the affected toe and the patient is asked to plantarflex the toe in order to prevent the paper strip from being pulled out. The test is positive if the patient is unable to provide sufficient plantarflexion to resist the pull of the paper strip (9).

DIAGNOSIS

In most cases, a comprehensive history and physical examination can provide sufficient information to diagnose lesser MPJ instability due to plantar plate injury. With clinical examination findings alone, Klein et al was able to correctly diagnose 95% of patients with plantar plate insufficiency (7). Another study by Sung et al reported a clinical examination accuracy rate of 91% in identifying plantar plate injury (10). Although clinical examination is very effective, there are many differential diagnoses to consider in the lesser MPJ region. These include MPJ capsulitis, bursitis, synovitis, interdigital neuroma, distal metatarsal head stress fracture, Freiberg’s disease, synovial cyst, osteochondral lesions, degenerative arthritis, and systemic arthritis (2,3,7).

Imaging can provide valuable information when clinical examination findings alone are unable to provide a clear diagnosis. Weightbearing plain film radiographs should be routine in the workup of lesser MPJ pain and is useful...
in evaluating the magnitude of angular deformity, joint congruity, arthrosis, and metatarsal length (3, 4). Dorsal subluxation and medial or lateral deviation of the proximal phalanx on the metatarsal head should raise suspicion of a plantar plate injury (3).

Magnetic resonance imaging (MRI) is helpful in identifying specific injury to the plantar plate, but should be reserved in cases where the clinical examination is questionable (3, 4). On T2-weighted sequences, a ruptured plantar plate will exhibit an area of discontinuity and increased signal intensity that is isointense with the synovium and synovial fluid (10, 11). In a prospective study by Sung et al, MRI was found to have a 95% sensitivity and 100% specificity in the diagnosis of plantar plate tears (10).

Arthrography with fluoroscopy has also been shown to be useful in the evaluation of the plantar plate. Radiopaque contrast is injected into the MPJ capsule, and extravasation of the contrast material into the flexor tendon sheath is diagnostic for a plantar plate rupture (3, 4). Mazzucca et al reported a 88% sensitivity and 63% specificity with plain arthrography (12).

**SURGICAL TREATMENT**

**Plantar Approach**

Through a plantar step-down or longitudinal incision, the plantar plate is able to be visualized and repaired directly via wedge resection or end-to-end repair (3, 4, 13). Brosky et al proposed direct plantar plate repair through a plantar approach with radiofrequency coblation and the addition of a proximal interphalangeal joint (PIP) arthrodesis if necessary. Radiofrequency coblation is reported to increase angiogenesis with minimal damage to surrounding healthy tissue (13).

The plantar approach has raised questions regarding the potential wound healing complications and painful plantar scar (3, 4, 14). In a recent retrospective study by Prissel et al, 144 plantar plates were repaired through a plantar approach. At a mean 6.5 month follow-up, 87.1% of the repairs were reported as good/excellent/well-aligned and reflected an appropriate clinical success rate and statistically significant evidence for postoperative improvement in pain, function, and disability according to modified Foot Function Index (FFI) scores (P < 0.001). However, the self-reported patient satisfaction questionnaire at a mean 22 month follow-up yielded suboptimal findings as nearly a third (31.6%) reported a painful plantar scar and 38.2% were somewhat dissatisfied or extremely dissatisfied with the surgery. Complications included wound problems (4.2%), recurrence (7.6%), and revision (2.8%) (14).

In theory, direct plantar plate repair through a plantar approach was aimed to provide direct visualization of the plantar plate injury, but a plantar approach may not always be able to visualize the tear (15). A cadaveric study by Cooper and Coughlin found that most plantar plate tears are incomplete tears with damaged dorsal fibers and intact plantar fibers. Through a plantar approach, these tears would not be able to be visualized since the plantar fibers would still be intact (16). In a retrospective study by Powless and Elze, 9 of 58 MPJ capsule repairs included a plantar plate repair. They discovered that an additional dorsal incision was commonly required to visualize the tear from within the joint despite an initial plantar approach (17).

**Dorsal Approach**

Plantar plate repair through a dorsal approach has gained popularity for many reasons. The dorsal approach avoids a plantar scar and allows direct repair of the plantar plate without disturbing the MPJ plantar flexor apparatus (4, 15). This retains the pulley mechanism of the digit and decreases the risk of disrupting the vascular supply to the affected toe (4, 15, 16).

With the recent innovations in commercially available suture passers, dorsal exposure of the plantar plate can be achieved without the need for a Weil osteotomy (2, 4). Additionally, a single dorsal incision can allow for adjunctive procedures if necessary (15).

Nery et al performed a prospective study of 100 plantar plate repairs through a dorsal approach and operative treatment was dictated by Coughlin’s anatomic grading system (18). Anatomic grade was assigned after diagnostic arthroscopy and they defined grade 0 as plantar plate attenuation, grade 1 as transverse distal or midsubstance tears <50%, grade 2 as transverse distal or midsubstance tears >50%, grade 3 as longitudinal tears and/or transverse tears, and grade 4 as extensive tears with button hole or degeneration. Grade 2 and 3 tears were treated with plantar plate repair via a dorsal approach, Weil osteotomy, and lateral capsular reefing. At the mean 2 year follow-up, they found that all groups improved with regard to joint stability after surgical treatment, with a 86.7% improvement in grade 2 tears, and 60.6% improvement in grade 3 tears. American Orthopedic Foot and Ankle Society (AOFAS) score improved significantly for all patients by mean 15 points (P < 0.0001). AOFAS scores for grade 2 tears improved from 44.3 to 84.7 and grade 3 tears 42.4 to 84.7. Visual analog scale (VAS) scores improved significantly in all groups (P < 0.0001) and all patients returned to “nonpain” or “mild pain” status after surgery. VAS scores for grade 2 tears improved from 7.8 to 0.7 (P < 0.0001), and grade 3 tears 8 to 1.2 (P < 0.0001) (18).

A more recent prospective study by Flint et al looked at 138 plantar plate repairs through a dorsal approach with a Weil osteotomy (5). Only 15 cases were isolated plantar plate repairs, and the majority of toes underwent concomitant procedures to address adjacent deformities. At the 1 year
follow-up, 80.4% reported good-excellent postoperative patient satisfaction scores. VAS score improved significantly from 5.4 to 1.5 ($P < 0.001$), AOFAS score improved significantly from 49 to 81 ($P < 0.001$), and MPJ stability improved from 0% to 96%. Of note, there was a significant decrease in both active and passive range of motion (ROM). Active ROM of the second MPJ decreased from 43 degrees to 34 degrees ($P < 0.05$), and passive ROM decreased from 76 degrees to 46 degrees ($P < 0.05$). The authors concluded that plantar plate repair through a dorsal approach was a viable treatment option for MPJ instability, although the results were likely biased due to the variability in recovery, pain, and subjective results of the concomitant procedures (5).

**DISCUSSION**

The plantar plate is the major structure that stabilizes the MPJ (2–4). Increased stress to the MPJ, whether biomechanic or traumatic, can lead to attenuation and tearing of the plantar plate. If left untreated, this can cause progressive, painful subluxation or dislocation of the proximal phalangeal base on the metatarsal head (3). Historically, the surgical management of lesser MPJ instability involved indirect repair of the deformity with soft tissue releases, tendon transfers, and metatarsal osteotomies (15). However, none of the previously mentioned indirect procedures address the primary source of pain and instability around the toe, which is due to the failure of the plantar plate and collateral ligaments (18). Improved understanding of the anatomy, biomechanics, and function of the plantar plate has led to the development of direct plantar plate repair techniques (2). A plantar approach provides a more direct repair allowing for increased plantarflexion of the proximal phalanx. However, recent evidence favors a dorsal approach to plantar plate repairs as it avoids a plantar scar and offers the surgeon the freedom to perform adjunctive procedures without another incision (2,3,4,5,15,18). Furthermore, the technical advances in surgical instruments and equipment allow for an efficient plantar plate repair through a dorsal approach without the need for additional procedures or extensive dissection (2, 4).

**REFERENCES**

THE LEADING PODIATRY EHR
Ask us about our cloud and billing service offerings!

Sammy
Electronic Health Records for Podiatrists

No Startup fee!
Revenue Cycle Management
Podiatry Specific EHR
Ongoing Education and Unlimited Support
Patient Engagement

Proudly serving Podiatrists for over 32 years

Sales: (888) 680-5711
www.thesammysystems.com

Support: (516) 766-2129
support@icssoftware.net
Cosmetic ingredients that rehydrate and restore skin and nail.
- N-acetyl-l-cysteine & Urea for better penetration.
- Tea Tree Oil adds benefits of antifungal, antiseptic, germicidal and anti-bacterial properties.
- Paraben-Free formulation
- A new ½ fl. oz. (15ml) tube with an integrated brush applicator for ease of use.
- Office dispensed – no prescription.
- 3 month supply
- The treatment improves appearances, softens, and moisturizes.

TETRA CORPORATION
INNOVATION • RESEARCH • INTEGRITY • SOLUTIONS
800-826-0479 • www.TheTetraCorp.com

Another First... The First Microemulsion Antifungal

TETRA CORPORATION INNOVATION TIMELINE

Formula 3®
Tetra introduces its patented topical antifungal with tolnaftate in solution.

FungiFoam®
A macroemulsion formulated with Tetra’s oil soluble tolnaftate.

Clean Sweep®
The first nontoxic shoe spray that is reactivated when patient wears shoes.

Kamea 20® and Kamea G®
Medical grade emollient and exfoliant formulated specifically for the foot.

Formula 7®
The first tolnaftate microemulsion with N-acetyl-l-cysteine, Urea, and Tea Tree oil.

2006 2012 2013 2014 2018

Delivering Value To Podiatry with Safe and Effective Products Since 2006.