CHAPTER **41**

UPDATE ON SECOND METATARSOPHALANGEAL JOINT INSTABILITY

Annalisa Y. Co, DPM
John A. Ruch, DPM

Recently, second metatarsophalangeal joint (2nd MTPJ) instability has become an annual topic of debate. Due to the challenges of this clinical entity, the variety of etiology and surgical treatment continues to broaden. From etiologies such as biomechanical induced synovitis or anatomical insufficiency, or treatments such as digital contracture management to second metatarsophalangeal joint arthrodesis,[1] the podiatric and orthopedic philosophies vary for this dehabilitating problem. The authors will discuss a comprehensive review of 2nd MTPJ instability.

ANATOMY

The 2nd MTPJ consists of the second metatarsal and proximal phalanx. The joint capsule that surrounds the 2nd MTPJ is blended with the short and long extensor dorsally forming the extensor apparatus. The plantar portion of the joint capsule and distal slips of the plantar aponeurosis forms a fibrous plate similar to the hand's volar plate. It is called the plantar plate and is approximately two millimeters to five millimeters thick.[2] The plantar plate is firmly attached to the base of the proximal phalanx and loosely attached to the metatarsal neck.[2,3] There are two sets of collateral ligaments in the region of the 2nd MTPJ, the accessory collateral ligaments (ACL) and the proper or phalangeal collateral ligaments (PCL).[4,5] The ACL, or metatarsoglenoid ligament, originates from the anterior superior metatarsal neck and inserts on to the plantar plate. The PCL, or metatarsaophalangeal collateral ligament,[4] originates from the anterior superior portion of the metatarsal head and inserts on the plantar base of the proximal phalanx. Longitudinally, the deep transverse intermetatarsal ligament (DTIL) connects the 1st MTPJ capsule and sesamoid apparatus to the 2nd MTPJ plantar plate[4,5] theoretically in a bifurcate fashion.[6] The conjoined tendon of adductor hallucis commonly passes between this hypothesized bifurcation.

Sagittal stability is maintained by dynamic balance of the extensors dorsally and flexors plantarly. The intrinsic lumbricales and interossei also assist in the muscle tendon balance of the 2nd MTPJ. The short and long flexors are able to glide within a central groove on the plantar plate. The surrounding flexor sheath has small attachments to the plantar plate. The plantar plate has also been hypothesized to maintain sagittal balance and stability.

Transverse stability is thought to be maintained by the PCL. Cadaver studies have shown that the collateral ligaments and plantar plate are the stabilizing structures for the 2nd MTPJ when straight vertical force is applied.[7] Others have also indicated the intrinsic muscle attachments, two dorsal interossei and the first lumbricale dynamically controls the second toe.[8] With a normal anatomical 2nd MTPJ, the lateral capsule is intact and the 2nd lumbricale's unopposed adduction force is minuscule owing to its small size.[8]

DEFINITION AND STAGING

Second MTPJ instability is inflammation of the joint and/or periarticular structures that can lead to multiplanar malalignment. Instability at the MTPJ has many different terminologies including Predislocation Syndrome,[9,10] Plantar plate dysfunction,[11] monarticular nontraumatic synovitis,[12] capsulitis/synovitis, metatarsalgia, and crossover toe. There has also been various staging and classifications for 2nd MTPJ instability. In 1995, Yu and Judge coined the term "Predislocation Syndrome" and staged the progression of this deformity (Figures 1A–C).

Stage I.

- Subtle, mild edema dorsal and plantar to the lesser MTPJ.
- Exquisite tenderness plantar and distal to the joint.
- Alignment of the digit clinically and radiographically appears unchanged compared to the contralateral digit.

Stage II.

- Moderate edema.
- Noticeable deviation of the digit both clinically and radiographically.
- Loss of toe purchase, noticeable in weight bearing.

Figure 1A. Stage I of Predislocation syndrome.

Figure 1B. Stage II of Predislocation syndrome.

Figure 1C. Stage III of Predislocation syndrome

Stage III.

- Moderate edema.
- Clinically, the deviation (sometimes frank subluxation or dislocation of the digit) is more pronounced.
- Subluxation or dislocation is evident radiographically.

In 2002, Fleming and Camasta coined the term "Plantar Plate Dysfunction" and also staged the progression according to results of the modified Lachman's test.[11] They divided the stages into a Predislocation stage by a negative Lachman's test, a Subluxation stage with ability to dorsally sublux approximately 50%, and a Dislocation stage that can dorsally dislocate near 100%.

ETIOLOGICAL THEORIES

The exact etiology of the 2nd MTPJ instability is still unclear. The orthopedic literature first hypothesized that tight stockings and high-heeled shoes maintained the digits in constant hyperextension leading to subluxation and dislocation of the 2nd MTPJ.[13] More recently, multiplanar deformity of the 2nd digit is likely due to lateral capsular and collateral ligament disruption with resultant plantar plate displacement and injury.[14] This cascade is most likely multi-factorial and is triggered by a combination of biomechanical and anatomical factors. Any abnormality, injury, or force on the anatomical complex of the 2nd MTPJ can cause a muscle-tendon imbalance leading to weakening of the stabilizing structures, inflammation, and pain. Following are different hypothesis on the etiology of 2nd MTPJ instability.

Accessory Tendons[15]

An accessory tendon has been noted in a cadaver study in some 2nd digit crossover deformities. This extra tendon originated for the extensor digitorum brevis which courses medially along extensor digitorum longus inserting on the dorsal-medial aspect of the second proximal phalanx base.

Long Second Metatarsal[16-19]

Second MTPJ instability has been thought to be structural in etiology if the 2nd metatarsal was abnormally long. A long metatarsal has been thought to instigate 2nd MTPJ instability by causing a digital contracture with increased pressure through metatarsal head. Abnormal weight-bearing forces on to the plantar plate beneath in toe-off will cause deterioration over time. This etiology may cause 2nd MTPJ instability without a transverse plane component.

Collateral Ligament Injury[5, 17]

It has been proposed that 2nd MTPJ transverse instability was a result of erosion of the proper collateral ligament and lateral joint capsule. Once the lateral collateral ligament, lateral joint capsule and/or second dorsal interossei have attenuated, there is potential for the plantar plate to medially dislocate. The first lumbricale, which is now unopposed, and extensor tendons influence progression of the deformity into subluxation with eventual frank dislocation of the 2nd MTPJ. Deland proposed to primarily repair the collateral ligaments in surgical treatment for 2nd MTPJ instability.[7]

Plantar Plate Injury[11, 20-22]

Pathology to the plantar plate has been thought to lead to attenuation and/or eventual through and through rupture. An MRI study revealed that plantar plate ruptures typically occur at the distal lateral attachment on the proximal phalanx.[23] Without an intact plantar plate, there is a diminished plantar-grade force of the proximal phalanx on the metatarsal head leading to loss of digital purchase. It's been described that with attenuation and deviation of the plantar plate, the flexor tendons dislocate and act as abductors or adductors progressing the 2nd MTPJ transverse deformity further.[24, 25, 37] Coughlin hypothesized chronic dorsal extension at the MTPJ leads to diminished plantarflexory force because the intrinsics are pulling down at a 90-degree angle.[8] Without plantarflexory power at the MTPJ, stretching and attenuation of the plantar periarticular structures including the plantar plate can occur. Also, cadaver studies have demonstrated that sectioning the plantar plate along with the collateral ligaments destabilizes the MTPJ while a straight vertical force is applied.[22]

Lesser Metatarsal Overload[8, 13, 20,26, 27]

It has been hypothesized that 2nd MTPJ instability may be generated from abnormal weight-bearing transfer on to the lesser metatarsals in the presence of 1st ray pathology. This is the result from a cascade of events beginning with equinus leading to a unstable, hypermobile medial column and 1st ray pathology such as hallux abductovalugs (HAV) or elevatus. This leads to decreased weight-bearing force under the 1st MTPJ and increased weight-bearing force under the lesser MTPJs. With pathological increased weight, damage or injury is thought to occur to the MTPJ plantar periarticular structures such as the plantar plate.

Deep Transverse Intermetatarsal Ligament (DTIL) Pathological Vector[28]

In 1990, the DTIL was first described as a pathological force on the 2nd MTPJ causing instability. As mentioned before, there is an intimate relationship of the DTIL connecting the capsule of the 1st metatarsal head and sesamoid apparatus to the 2nd MTPJ's plantar plate.[4, 5] In 1983, Ruch stated that any force from the first ray, such as dorsiflexion, will create a moment of lateral pull from the DTIL. The moment will have an effect on the perarticular structures including the fibular sesamoid and adductor tendon leading to progression of a hallux valgus deformity.[29] Concurrently, there is an opposite, yet smaller, pull medially through the DTIL. Since the plantar plate is firmly attached to the base of the proximal phalanx and loosely to the metatarsal head, the digit will move in a medial direction as the 1st ray pathology increases. In the presence of a constant medial pull on the plantar plate, inflammation and weakening of the structures will occur including attenuation and rupture. 1st ray pathology which can interrupt the balance of the periarticular structures causing pull of the DTIL include HAV (Figures 2A, 2B), hallux extensus, or a dorsiflexed or plantarflexed 1st metatarsal. Other anatomical restraints can include a short or long 1st metatarsal or 2nd metatarsal.

Iatrogenic

After surgical repair of 1st ray pathology or 2nd digit, subluxation at the MTPJ can occur. Coughlin had four patients in his study on crossover 2nd toe deformity that developed 2nd MTPJ instability six to ten years after hallux valgus repair.[17] This theory overlaps with the DTIL theory in that 2nd MTPJ instability can occur with any

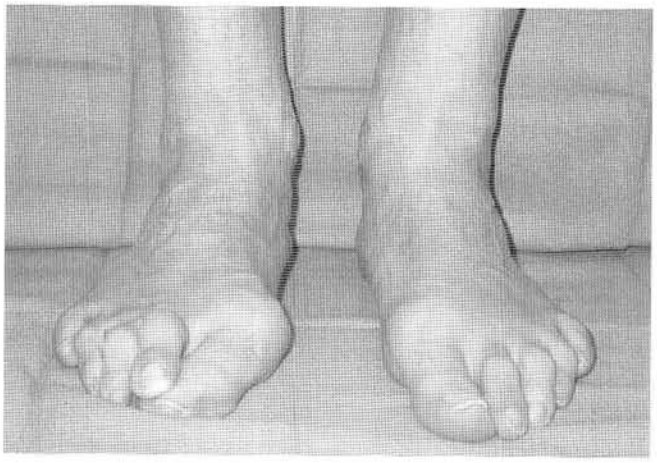

Figure 2A. With first ray pathology such as HAV, the DTIL can serve as a defroming force predisposing second MTPJ instability. Note the opposite foot with a recturs first ray.

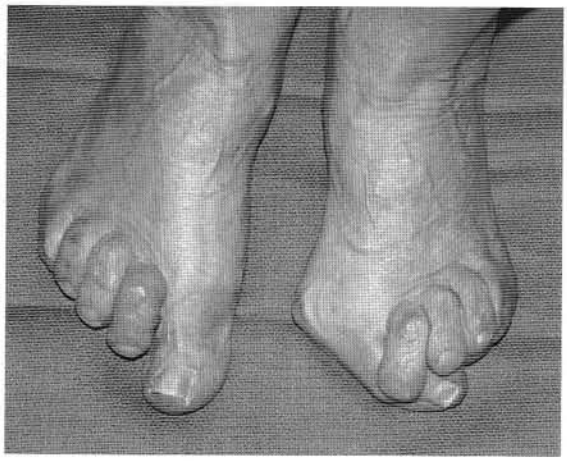

Figure 2B.

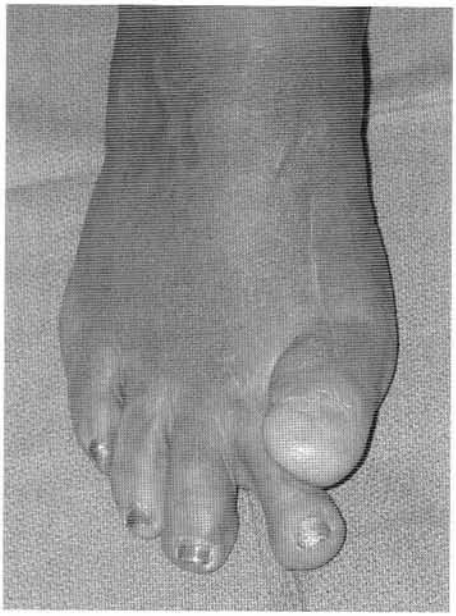

Figure 3A. Iatrogenic 2nd MTPJ instability can be predisposed by shortening of the first metatarsal. This patient presented with a surgical history consisting of a distal amputation of the hallux, bunionectomy, and first MTPJ arthrodesis.

Figure 3B.

disruption of the anatomical balance of the DTIL and 1st MTPJ periarticular structures. Examples include any surgical intervention which plantarflexes, dorsiflexes, or shortens the 1st metatarsal (Figures 3A, 3B). Theoretically surgical intervention for HAV with any osteotomy will have some degree of shortening which also affects the sesamoid apparatus therefore the DTIL. Adductor tendon transfer for HAV should hypothetically place slack in the DTIL due to its repositioning the sesamoid apparatus to its anatomical position.

CLINICAL SIGNS AND SYMPTOMS

The physical appearance of 2nd MTPJ instability can vary from a perfectly aligned digit to a completely dislocated and overlapping or underlapping digit. The pathology can be single or multiplanal. Some appear similar to a simple hammertoe with pure sagittal malalignment where others can have transverse instability medially or less common, laterally (Figures 4A, 4B). At times there can also be accompanied varus or valgus rotation with the transverse malalignment of the digit.

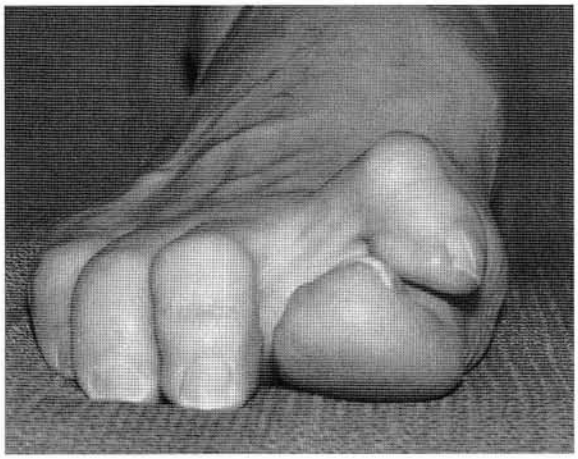

Figure 4A. Most common, a severely dislocated second digit will medially overlap the hallux.

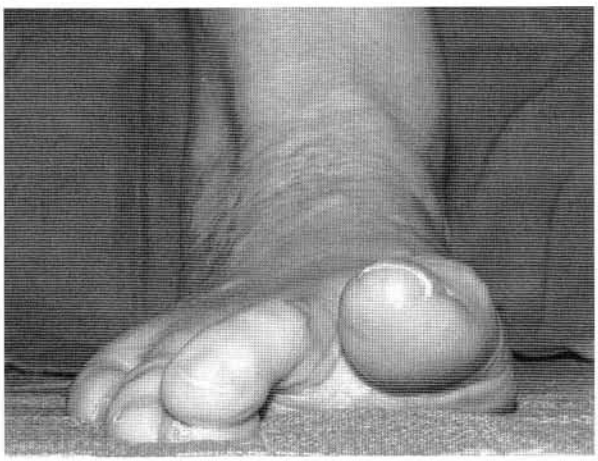

Figure 4B. Rarely, second MTPJ instability can present with a laterally deviated digit.

Figure 5. The chief complaint of late second MTPJ instability may be a painful lesion at the dorsal aspect of the second PIPJ.

Second MTPJ instability is described to be very painful "in the ball of the foot" with weightbearing. The patient may describe a sensation of stepping on a stone or mass. This pain is out of proportion to the clinical appearance especially in an early 2nd MTPJ instability that clinically has no digital deformity. Pain and/or a lesion can be present at the dorsal proximal interphalangeal joint area if there is a significant deformity (Figure 5). Edema may also be present in the area of the 2nd MTPJ. Symptoms of 2nd MTPJ instability are rarely neuritic in nature though this clinical entity is commonly misdiagnosed as a second innerspace neuroma.

DIAGNOSIS

A subluxed or dislocated 2nd digit is an immediate sign of 2nd MTPJ instability. Typically, exquisite pain on palpation near the area of the plantar base of the proximal phalanx, where the plantar plate is firmly attached, is indicative of 2nd MTPJ instability. Pain with maximal dorsiflexion rather than plantarflexion is also a sign of this pathology. Avascular necrosis of the 2nd metatarsal head or "Freiberg's Infarction" can be differentiated easily due to its arthritic symptoms, loss of range of motion, no direct plantar proximal phalanx base pain on palpation, and the radiographic changes with arthritic flattening of the metatarsal head.

A modified Lachman's test is used to determine existing instability and inflammation of the 2nd MTPJ. Described by Thompson and Hamilton,[18] the Lachman's test is performed with one hand holding the 2nd digit at the base of the proximal phalanx in slight dorsiflexion, and the other stabilizing the 2nd metatarsal. Vertical dorsal translation of the 2nd digit from the metatarsal head is a positive test result and confirms plantar anatomical irregularity. It is imperative that digital dorsiflexion is not interpreted as a positive Lachman's test result. In early 2nd MTPJ instability, there may be exquisite plantar pain associated with attempt of a Lachman's test even if the result is negative.

Plain radiographs may exhibit dorsal and medial or lateral subluxation or dislocation at the 2nd MTPJ. There may be a decreased space between the 2nd and 3rd metatarsal heads when compared to the remainder intermetatarsal spaces. A longer 2nd metatarsal may be present along with cortical hypertrophy compared to the other metatarsals. 1st ray pathology should also be noted for the possible surgical treatment plan.

Magnetic resonance imaging (MRI) has been used as an ancillary diagnostic tool for 2nd MTPJ instability.[23,30] Yao et al. advocated using a small receiver coil and three-dimensional image acquisition techniques[31] to view the plantar periarticular structures. With a rupture of the plantar plate, there will be increased signal intensity at the area of the proximal phalanx attachment site on a T2W image. The joint capsule and flexor sheath is also intensified on a T2W image due to capsulitis and synovitis. Other findings may include thickening of the plantar plate on a T1W image and/or edematous changes along the deep transverse intermetatarsal ligament and distal plantar fascia slips on a T2W image.

A Tc99 bone scan will have increased uptake in the region of the 2nd MTPJ. The uptake of tracer will appear in the flow study due to its inflammatory nature. Bone scans are sensitive to inflammatory processes, but minimally specific in making a diagnosis.

Arthrography has also been a useful tool in diagnosing 2nd MTPJ instability.[30, 32] By injecting a small amount of iodinated contrast into the 2nd MTPJ with the aid of fluoroscopy, a rupture of the plantar plate can be diagnosed by outflow into the flexor tendon sheath. The dye will only enter the flexor tendon sheath with a significant defect of the plantar structures therefore mere attenuation or early 2nd MTPJ instability will not have a positive arthrogram.

Local anesthetic block for diagnosis can be injected into the MTPJ. If the symptoms resolve, a 2nd innerspace neuroma can be ruled out as a differential.

Cross-over taping described by Yu and Judge for conservative treatment can also be diagnostic. When applying the tape to the 2nd MTPJ, stability of the joint is accomplished, and there is immediate relief of symptoms.

CONSERVATIVE TREATMENT

All treatment should begin with conservative measures. Cross-over taping the 2nd MTPJ will stabilize the joint and give immediate relief for the patient while aiding with the diagnosis. This inhibits any extension or dorsal migration of the phalanx from the metatarsal head. Functional foot orthoses and rocker-sole shoe modifications have been advocated in the literature to mechanically control forefoot pressure on the 2nd MTPJ.[33] Metatarsal padding can also be fabricated to off-weight the 2nd metatarsal head. This type of padding can be used alone or in combination with an orthotic device. Non-steroidal anti-inflammatory drugs (NSAIDs) can be used to help decrease the inflammatory process.[12] Corticosteroid injections have been previously advocated to calm the acute inflammation.[33] Caution should be used with steroid injections to prevent further weakening of the joint structures.

SURGICAL TREATMENT

Surgical treatment is aimed to repair and restore the alignment and function of the 2nd MTPJ.[34] The surgical intervention should allow proper muscle-tendon balance of the MTPJ and regain its intrinsic ligamentous stability. Most 2nd MTPJ instability has associated 1st ray pathology, thus 1st ray and/or medial column stabilization may need to be performed along with the 2nd MTPJ procedure of choice. There is a list of surgical procedures in the literature addressing 2nd MTPJ instability; unfortunately there are not any long-term studies in reducing the deformity and pain, and most important, preventing recurrence. The following are procedures commonly used by The Podiatry Institute to repair 2nd MTPJ instability.

Proximal Interphalangeal Joint Arthrodesis with Metatarsophalangeal Joint Release[8, 35] (Figures 6A, 6B)

With proper soft tissue release and PIPJ arthrodesis, stability and realignment may be achieved for mild to moderate 2nd MTPJ instability. Dissection includes a linear midline incision over the PIPJ to avoid all neurovascular structures. Anatomical dissection is carried through the skin and superficial fascia exposing the deep fascia overlying the extensor tendons. A transverse extensor tenotomy/capsulotomy followed by transaction of the medial and lateral collateral ligaments will expose the head of the proximal phalanx. If the sagittal component of the digital contracture is significant, an extensor Z-lengthening may be necessary. A McGlamry elevator can also be used to release resistant plantar adhesions of the 2nd metatarsal head which can inhibit proper flexion at the MTPJ. A 0.045 or 0.054 inch smooth Kirschner wire (k-wire) is used to fixate the arthrodesis.

Additional procedures to realign the 2nd digit can include extensor hood recession, MTPJ capsulotomy and pinning through the MTPJ with the k-wire. Post-operative care includes full weight-bearing in a surgical shoe or a surgical shoe padded to the plantar sulcus if the k-wire is pinned through the MTPJ. The k-wires should be removed after a minimum of five to six weeks.

Flexor Tendon Transfer[8, 10, 20, 22, 36-38]

For a reducible or semi-reducible contracture, which is mainly in the sagittal plane, a PIPJ arthrodesis with flexor tendon transfer may be required to return the digit to a

Figure 6A. Preoperative PIPJ arthrodesis with MTPJ release and K-wire fixation.

Figure 6B. Postoperative PIPJ arthrodesis.

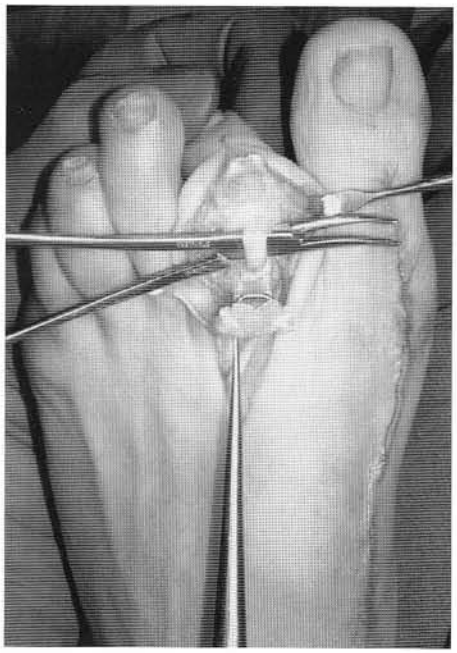

Figure 7. When performing a flexor tendon transfer for second MTPJ instability, the long flexor tendon can be accessed dorsally after preparing the PIPJ surfaces for arthrodesis.

normal purchasing configuration. By relocating the flexor tendon dorsally, the loss of intrinsic plantarflexory function would be replaced by the flexor muscles.[34]

After preparing the PIPJ surfaces for arthrodesis, the long or short flexor can be transferred dorsally through the PIPJ (Figure 7). At the joint level, the two slips of the short flexor are superficial and can be retrieved after incising through its flexor sheath. More often, the long flexor is preferred and a hemostat or freer-elevator is used to separate the short flexor slips in order to obtain it. Before severing the flexor tendon of choice to transfer, a 3.0 non-absorbable suture can be used to fasten the short and long flexors together distally. This is to preserve proper flexion ability of the digit post-operatively. The long flexor tendon is then incised just proximal to the suture, split proximally to the base of the proximal phalanx into two separate slips, and brought dorsally onto the proximal phalanx. A 3.0 non-absorbable suture is used to lock the tendon ends together dorsally under appropriate tension bringing the digit in a more plantar grade position. The PIPJ arthrodesis is performed as above.

Additional procedures to the flexor tendon transfer and PIPJ arthrodesis include MTPJ release with wire fixation, McGlamry elevator to release plantar adhesions of the 2nd metatarsal head, and/or a plantar/lateral retention stitch. Post-operative care includes non-weight bearing for four to six weeks with k-wire removal after a minimum of five to six weeks.

Plantar-Lateral Retention Stitch[21, 39, 40]

In 2000, Deland and Sung performed a cadaver dissection on a "medial crossover toe" and found that the medial ligaments were shortened by approximately 20% and the lateral portion of the plantar plate was attenuated.[24] For medial subluxation or deviation of the 2nd digit, medial capsular release with plantar/lateral capsular reinforcement may be indicated.

Dissection is identical for release of the MTPJ. Any adhesions between the metatarsal head and plantar plate may be released with the McGlamry elevator.[14] The normal dorsal MTPJ capsulotomy is first performed. For a medially deviated digit, a section of the medial plantar plate can be excised before tightening laterally.[40] A 0 or 2.0 non-absorbable suture is used in a single vertical retention-type stitch at the plantar-lateral portion of the MTPJ capsule. This stitch includes the lateral portion of the plantar plate, the lateral collateral ligaments, and the lateral joint capsule (Figure 8A & 8B). The suture is tightened with the digit in an overcorrected position laterally.

Additional stabilizing procedures can include PIPJ arthrodesis with K-wire fixation through the MTPJ. Postoperative care includes full weight-bearing in a surgical shoe or surgical shoe padded to the plantar sulcus if pinned through the MTPJ.

Collateral Ligament Repair[7, 21, 41, 42]

The MTPJ collateral ligaments can be replaced with the extensor digitorum brevis (EDB) tendon. In a laterally deviated digit, the EDB tendon can be used as a strap through an oblique drill hole in the metatarsal neck to create a new medial collateral ligament. For a medially deviated digit, the EDB can also be used through a drill hole in the plantar-lateral proximal phalanx as a tether to stabilize the MTPJ. Another collateral repair technique describes leaving the distal insertion of the EDB intact, and rerouting the proximal loose tendon plantar to the DTIL and then attaching it to itself. The interossei have also been used to repair the collateral ligaments. A drill hole in the head or neck of the metatarsal is created and the first dorsal interossei is used to replace the lateral collateral ligament.

Additional stabilizing procedures can include PIPJ arthrodesis with K-wire fixation through the MTPJ. Postoperative care includes full weight-bearing in a surgical shoe.

Plantar Plate Repair[11, 20, 43, 44]

Repairing the plantar plate for 2nd MTPJ instability is well documented in the literature. With attenuation or frank rupture, repair of the plantar plate can be advantageous in returning stabilization to the MTPJ.

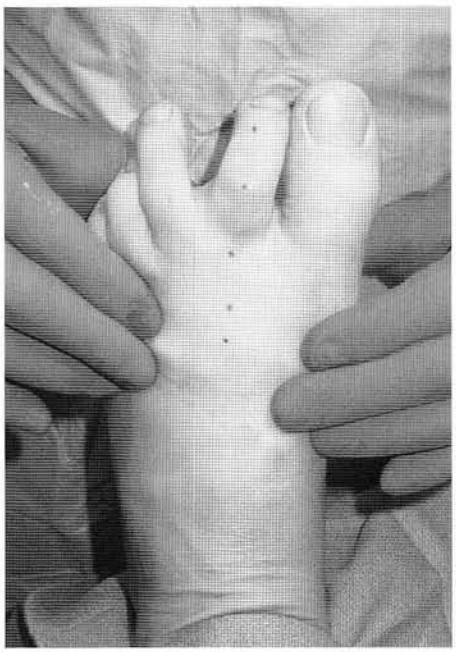

Figure 8A. The plantar-lateral retention stitch includes the lateral portion of the plantar plate, the lateral collateral ligaments, and the lateral joint capsule with 0 or 2.0 non-absorbable suture.

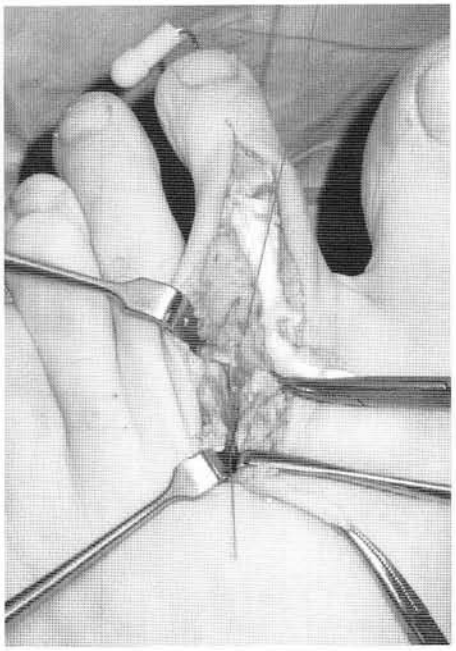

Figure 8B.

Using a plantar approach, a small vertical linear incision is made overlying the 2nd MTPJ region. Sharp dissection is used through the subcutaneous tissues until the flexor tendon sheath is encountered. A longitudinal incision through the sheath will expose the long and short flexor tendons where they can be retracted medially. The plantar plate is now exposed into the surgical wound where exploration and repair can now be achieved. At the area of pathology, a small section encompassing the damaged plate can be removed. Next, the two clean edges can be reapproximated and sutured. It has been advocated to take a wedged section of the plantar plate to attempt for transverse plane correction. 0 or 2.0 non-absorbable suture is used to reapproximate the plantar plate with the digit held in slight plantarflexion.

Additional stabilizing procedures can include PIPJ arthrodesis with K-wire fixation, MTPJ release, and flexor tendon transfer. Postoperative care includes full weight-bearing in a surgical shoe padded to the plantar sulcus to off-weight MTPJ.

Metatarsophalangeal Joint Arthroplasty[21, 45, 46]

For a significantly malaligned 2nd MTPJ, a MTPJ arthroplasty may be indicated. While some advocate taking three to four millimeters of bone from the metatarsal head,[21] the authors prefer to instead resect the base of the proximal phalanx to preserve the anatomical metatarsal parabola. Dissection begins identical to a hammertoe in exposing the PIPJ. Next the extensor tendons are released such that an extensor Z-lengthening is feasible. The MTPJ is released from its dorsal capsule, and medial and lateral collateral ligaments. Next, the periosteum is freed from the base of the proximal phalanx. With the use of an oscillating saw, the base of the proximal phalanx is resected. In order to prevent a floppy, non-purchasing digit after a base resection, the long flexor tendon can be reattached to the remaining proximal phalanx. Others have included syndactylization to prevent recurrence and instability. Fusion of the PIPJ should also be considered for maximal stabilization.

Additional procedures can include pinning through the MTPJ with a 0.062 in smooth k-wire if syndactly is not performed. Recently it has been noted that a PIPJ fusion with pinning across the MTPJ is sufficient to stabilize the digit and prevent recurrence (Figure 9A - 9C). Post-operative care includes non-weight bearing for four to six weeks with k-wire removal after a minimum of five to six weeks.

Metatarsal Osteotomy[35, 47-49]

If the 2nd metatarsal is significantly deviated laterally from its normal anatomical position (Figures 10A–10C), a distal metatarsal osteotomy may be indicated. Transpositional osteotomies attempt to relocate the metatarsal head into anatomical position, back over the plantar plate. Decompression of the MTPJ can also be accomplished with a distal metatarsal osteotomy. Another type of osteotomy for 2nd MTPJ instability is the laterally closing head osteotomy.[50]

Our standard distal transpositional metatarsal osteotomy begins with dorsal anatomical dissection exposing the 2nd MTPJ. Once the metatarsal head and neck are exposed, a through and through osteotomy created just proximal to the dorsal articular from dorsal-distal to proximal-plantar is created in a similar fashion as a dorsiflexory wedge osteotomy. The capital fragment can be translated medial and shortened for decompression. Fixation includes one or two 2.0-millimeter cortical screws inserted in standard AO lag technique.

Additional stabilizing procedures can include PIPJ arthrodesis with K-wire fixation with or without a flexor tendon transfer. Postoperative care includes non-weight bearing in a Jones compression cast.

CONCLUSION

In treating 2nd MTPJ instability, there are many ways one may approach this deformity. Dependent on which etiology one agrees with, a surgical treatment can then be decided. The etiology of 2nd MTPJ instability is multi-factorial therefore there is not one surgical treatment but a combination may be needed. The authors believe the biomechanical pathology lies within a deforming force from the DTIL. Studies including anatomical investigation and surgical treatment long-term results are actively ongoing.

Figure 9A. For a non-reducible dislocation of the second JPJ, a proximal phalanx base resection may be indicated. Preoperative radiograph.

Figure 9B. Immediate postoperative radiograph after base resection, PIPJ arthrodesis and K-wire fixation.

Figure 9C. Follow-up radiograph.

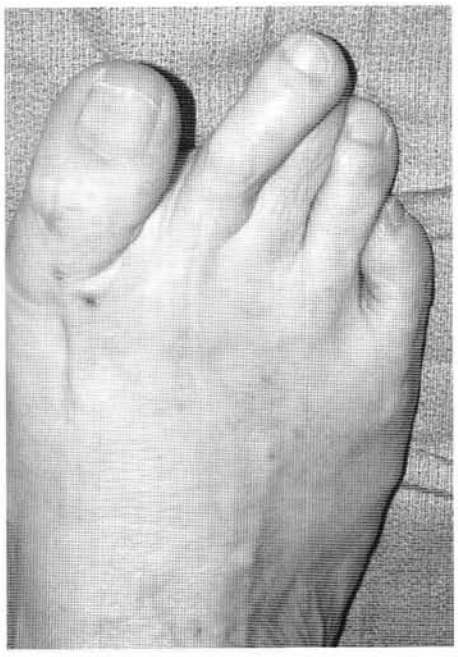

Figure 10A.

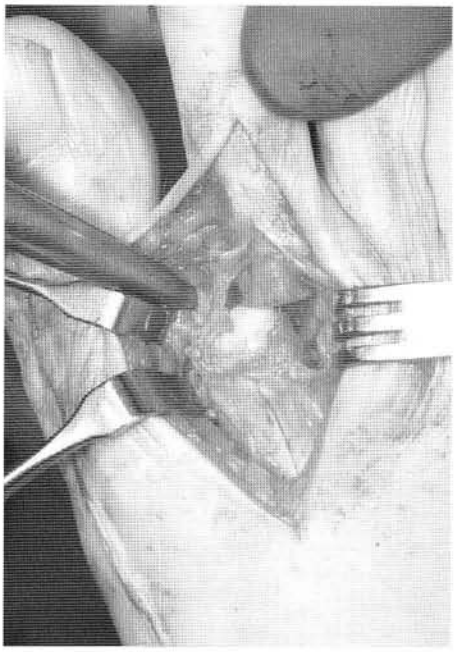

Figure 10B.

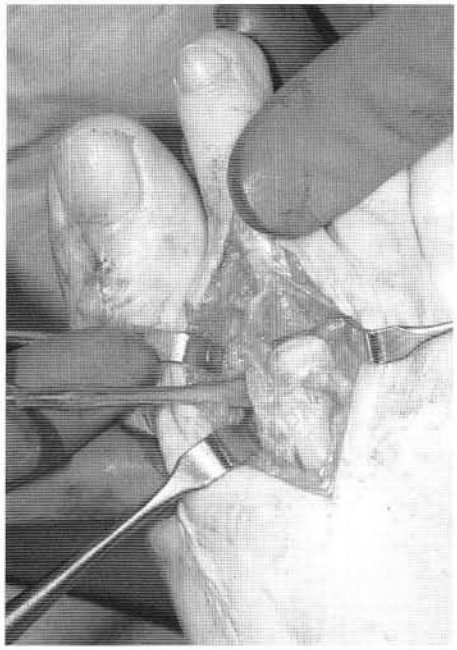

Figure 10C.

REFERENCES

1. Karlock LG. Second metatarsophalangeal joint fusion: a new technique for crossover hammertoe deformity. A preliminary report. *J Foot Ankle Surg* 2003:42:178-82.
2. Johnston RB, Smith JS, Daniels T. The plantar plate of the lesser toes: An anatomical study in human cadavers. *Foot Ankle Int* 1994:15:276-82.
3. Myerson MS, Shereff M. The pathologic anatomy of claw and hammer toes *J Bone Joint Surg Am* 1989:71:45-9.
4. Sarrafian SH. Anatomy of the foot and ankle. Philadelphia: J.B. Lippincott:1992 p. 207-11.
5. Deland JT, Sobel M, DiCarlo EF. Anatomy of the plantar plate and its attachments in the lesser metatarsophalangeal joint. *Foot Ankle Int* 1995:16:480-6.
6. Valvo P, Hochman D, Reilly C. Anatomic and clinical significance of the first and most medial deep transverse metatarsal ligament. *J Foot Surg* 1987:26:194-203.
7. Deland JT, Lobel M, Arnockzky SP, Thompson FM. Collateral ligament reconstruction of the unstable metatarsophalangeal joint: an in vitro study. *Foot Ankle Int* 1992:13:391-5.
8. Coughlin MJ. Subluxation and dislocation of the second metatarsophalangeal joint. *Orthop Clin North Am* 1989:20:535-51.
9. Yu GV, Judge M. Predislocation syndrome of the lesser metatarsophalangeal joint: a distinct clinical entity. In: Camasta CA, Vickers NS, Carter SR, eds. Reconstructive Surgery of the Foot and Leg. Update '95, Tucker (GA): Podiatry Institute; 1995. p.109-13.
10. Yu GV, Judge MS, Hudson JR, Seidelmann FE. Predislocation Syndrome. Progressive Subluxation/dislocation of the lesser metatarsophalangeal joint. *J Am Podiatr Med Assoc* 2002:92:182-99.
11. Fleming JF, Camasta C. Plantar plate dysfunction. In: Vickers, NS ed. The Proceedings of the Annual Meeting of the Podiatry Institute. Update '02, Tucker (GA): Podiatry Institute; 1998 p. 22-8.
12. Mann RA, Mizel MS. Monarticular nontraumatic synovitis of the metatarsophalangeal joint: a new diagnosis? *Foot Ankle Int* 1985:6:18-21.
13. Branch HE. Pathologic dislocation of the second toe. *J Bone Joint Surg Am* 1937:978-4.
14. Downey MS, McGlamry MC. Transverse Plane Digital Deformities. In: Banks AS, Downey MS, Martin DE. Miller SJ. Editors. McGlamry's Comprehensive Textbook of Foot and Ankle Surgery. 3rd ed. Baltimore (MD): Lippincott Williams & Wilkins; 2001. p. 354-72.
15. Hatch DJ, Burns MJ. An anomalous tendon associated with crossover second toe deformity. *J Am Podiatr Med Assoc* 1994:84:131-2.
16. Morton DJ. Metatarsus atavicus: The identification of a distinctive foot disorder. *J Bone Joint Surg Am* 1927:9:531.
17. Coughlin MJ. Crossover second toe deformity. *Foot Ankle Int* 1987:8:29-39.
18. Thompson FM, Hamilton WG. Problems of the second metatarsaophalangeal joint. *Orthopedics* 1987:10:83-9.
19. Fortin PT, Myerson MS. Second metatarsophalangeal joint instability. *Foot Ankle Int* 1995:16:306-313.
20. Ford LA, Collins KB, Christensen JC. Stabilization of the subluxed second metatarsophalangeal joint: flexor tendon transfer versus primary repair of the plantar plate. *J Foot Ankle Surg* 1998:37:217-22.
21. Myerson MS. Arthroplasty of the second toe. Seminars in arthroplasty 1992:3:31-8.
22. Bhatia D, Myerson MS, Curtis MJ, Cunningham BW. Anatomical restraints to dislocation of the second metatarsaophalangeal joint and assessment of a repair technique. *J Bone Joint Surg Am* 1994:76:1371-5.
23. Umans HR, Elsinger E. The plantar plate of the lesser metatarophalangeal joints. Potential for injury and role of mr imaging. *Magn Reson Imaging Clin N Am* 2001:9:659-69.

24. Deland JT, Sung Il-Hoon. The medial crossover toe: a cadaveric dissection. *Foot Ankle Int* 2000:21:375-78.
25. Johnson JB, Price TW. Crossover second toe deformity: etiology and treatment. *J Foot Surg* 1989:28:417-20.
26. Jahss MH. Miscellaneous soft-tissue lesions. In: Disorders of the foot, vol. 1 Philadelphia: W.B. Saunders Company; 1982, p. 843.
27. Fishco, WD. The sub-two syndrome. In: Miller SJ, Mahan KT, Yu GV, Camasta CA, Vickers NS eds. Reconstructive Surgery of the Foot and Leg. Update '98, Tucker (GA):Podiatry Institute; 1998 . p. 107-11.
28. Miller SJ. Transverse plane metatarsophalangeal joint deformity: Another etiology and solution. In: Miller SJ, Mahan KT, Yu GV, Camasta CA, Vickers NS eds. Reconstructive surgery of the foot and leg. Update '98, Tucker (GA):Podiatry Institute, 1998; p. 124-8.
29. Ruch JA. 12th Annual Surgical Seminar, Doctors Hospital Podiatric Education and Research Institute, Tucker (GA) ;1983 p. 57-63.
30. Yao L, Do H, Cracchiolo A, Farahani K. Plantar plate of the foot: Findings on conventional arthrography and mr imaging. *AJR Am J Roentgenol* 1994:163:641-5.
31. Yao L, Cracchiolo A, Farahani K, Seeger LL. Magnetic resonance imaging of plantar plate rupture. *Foot Ankle Int* 1996:17:33-6.
32. KarpmanRR, MacCollum MS. Arthrography of the metatarsophalangeal joint. *Foot Ankle Int* 1988:125-9.
33. Trepman E, Seng-Jin Y. Nonoperative treatment of metatarsophalangeal joint synovitis. *Foot Ankle Int* 1995:16:771-7.
34. McGlamry ED, Jimenez AL, Green DR. Deformities of the Intermediate Digits and the Metatarsophalangeal Joint. In: Banks AS, Downey MS, Martin DE. Miller SJ. Editors. McGlamry's Comprehensive Textbook of Foot and Ankle Surgery. 3rd ed. Baltimore (MD):Lippincott Williams & Wilkins: 2001; p. 253-304.
35. Graziano TA. Correction of crossover second toe deformity. *Clin Podiatr Med Surg* 1996:13:269-78.
36. Schuberth JM, Jensen R. Flexor digitorum longus transfer for second metatarsophalangeal joint dislocation/subluxation. In: Miller SJ, Mahan KT, Yu GV, Camasta CA,Vickers NS eds. Reconstructive surgery of the foot and leg. Update '97, Tucker (GA): Podiatry Institute; 1997 p. 11-4.
37. Thompson FM, Deland JT. Flexor tendon transfer for metatarsophalangeal instability of the second toe. *Foot Ankle Int* 1993:14:385-8.
38. Gazdag A, Cracchiolo A. Surgical treatment of patients with painful instability of the second metatarsophalangeal joint. *Foot Ankle Int* 1998:19:137-43.
39. Chambers GL. Correction of the transverse lesser mtpj deformity. In: Mahan KT, Miller SJ, Ruch JA, Yu GV, Vickers NS eds. Reconstructive surgery of the foot and leg. Update '01, Tucker (GA): Podiatry Institute; 2001 p. 11-21.
40. Ruch JA. A surgical technique for repair of the "pre-dislocation syndrome." In: Miller SJ, Mahan KT, Yu GV, Camasta CA,Vickers NS eds. Reconstructive surgery of the foot and leg. Update '97, Tucker (GA): Podiatry Institute; 1997 . p. 7-10.
41. Ruch JA. Use of EDB tendon for muscle-tendon balance of the lesser mtpj. In: Camasta CA,Vickers NS, Carter SR eds. Reconstructive surgery of the foot and leg. Update '95, Tucker (GA): Podiatry Institute; 1995 . p.114-8.
42. Haddad SL, Sabbagh RC, Resch S, Myerson B, Myerson MS. Results of flexor-to-extensor and extensor brevis tendon transfer for correction of the crossover second toe deformity. *Foot Ankle Int* 1999:20:781-8.
43. Castellano BD. The overlapping second toe: a preliminary investigation. In: DiNapoli DR, Vickers NS eds. Reconstructive surgery of the foot and leg: update '90. Tucker (GA): Podiatry Institute; 1990. p. 60-2.
44. Castellano BD. Transverse plane dislocation of the lesser metarsarsophalangeal joints. In: Ruch JA, Vickers NS, eds. Reconstructive surgery of the foot and leg: update '90. Tucker (GA): Podiatry Institute; 1990. p. 60-2.
45. Kelikian H, Clayton L, Loseff H. Surgical syndactylia of the toes. *Clin Orthop* 1961:19:208.
46. Daly PJ, Johnson KA. Treatment of painful subluxation or dislocation at the second and third metatarsophalangeal joints by partial proximal phalanx excision and subtotal webbing. *Clin Orthop* 1992:278:164-70.
47. Goforth WP, Urteaga AJ. Displacement osteotomy of the treatment of digital transverse plane deformity. *Clin Podiatr Med Surg* 1996:13:279-92.
48. Trnka HJ, Muhlbauer M, Zettl R, Myerson MS, Ritschi P. Comparison of the results of the weil and helal osteotomies of the treatment of metatarsalgia secondary to dislocation of the lesser metatarsophalangeal joints. *Foot Ankle Int* 1999:20:72-9.
49. Goecker RM. Decompression and transpositional osteotomy of a metatarsal head for transverse mtpj deformity. In: Mahan KT, Miller SJ, Ruch JA, Yu GV, Vickers NS, eds. Reconstructive surgery of the foot and leg. Update '01, Tucker (GA): Podiatry Institute; 2001. p. 22-5.
50. Berens TA. Laterally closing metatarsal head osteotomy in the correction of a medially overlapping digit. *Clin Podiatr Med Surg* 1996:13:293-307.