Direct Versus Indirect Repair: Which Is Superior for Plantar Plate Tears?

Point

Here the author draws comparisons with other joints outside of the foot and ankle, along with diving into evidence that supports direct repair as an anatomy-preserving choice for the plantar plate.

By Michael Theodoulou, DPM, FACFAS

The ideal biomechanical restoration of the unstable metatarsophalangeal joint provides for the normal static strength of the plantar plate to allow for the anatomic position of the toe in all cardinal planes of the body. Repair permits the dynamic stabilizers to maintain alignment and allow for the active purchase of the toe on the weight-bearing surface without the restriction of normal joint motion. Appropriate tensioning of deranged joints in their repair remains a challenge in orthopedics and is not unique to this area.

The commonly repaired anterior cruciate ligament of the knee remains under ongoing study and investigation to limit the long-term sequelae of its repair to include: persistent instability, pain, longstanding joint stiffness, and arthrosis. Similarly and most analogous to plantar plate injuries are those of the rotator cuff in the shoulder. Direct anatomic restoration of the glenohumeral joint remains the standard of care regardless of approach, including arthroscopic, open, or mini-open. Only when there is a severe deficiency of the anatomy should indirect or joint destructive procedures be considered, such as with reverse total shoulder arthroplasty. We should not think of lesser metatarsophalangeal joints differently. One should only consider indirect repair when there is insufficient anatomy to repair directly.

What Does the Evidence Reveal About The Surgical Approaches?

In 1998, Ford and colleagues published their early investigations of direct versus indirect repair of the subluxed metatarsophalangeal joints.[1] Using cadaveric models, the authors aimed to identify the comparative strengths of flexor tendon transfer versus direct repair. Their models appreciated statistical significance in the intact versus transected plantar plate regarding joint stability. They found similar outcomes between direct anatomic repair versus tendon transfer in restoring joint stability in repair.[1] Anatomic restoration of pathology should be considered advantageous.

I believe, and with experience, that indirect repair demands sacrificing functioning anatomy to achieve a less than ideal outcome. The often-used transfer of the long flexor tendon to the proximal phalanx demonstrates the challenges in joint tensioning. A successful transfer requires appropriate strength, amplitude, direction and attachment, synergy and phase of muscle, integrity, tensioning, and formation of a stable bone-to-tendon interface.[2] The most common complication to tendon transfer relates to tensioning and persistent joint stiffness. Multiple published studies acknowledge this complication.

In 1999, Haddad and his team assessed outcomes in repairing this condition, comparing transfer of the extensor digitorum brevis and the flexor digitorum longus.[3] In their study, the authors appreciated severe stiffness in 3 of 16 feet and mild stiffness in another 8 for those that underwent flexor digitorum longus transfer. Procedural restriction of joint motion limited to fifteen degrees of dorsiflexion demonstrated ongoing pain. Patients with the restored movement to thirty degrees of dorsiflexion showed no persistent discomfort.[3] Butterworth also appreciated the importance of physiologic tension in tendon transfer for this repair and suggested that surgeon discretion was critical without identified objective measures to facilitate.[4] She also appreciated that inadequate tension would result in recurrence, and over-tensioning promoted stiffness and overcorrection.[4]

Myerson and Jung also evaluated the role of flexor digitorum longus transfer for metatarsophalangeal joint instability.[5] Similar to most reports, this was not isolated but included other procedures. They concluded that many patients demonstrated an improved pain state. Still, many dissatisfied patients result from joint stiffness, and patients should have a complete understanding of complications and dissatisfaction.[5]

Prissel and colleagues reported on direct plantar plate repair outcomes with or without concomitant Weil osteotomy.[6] The authors retrospectively analyzed 131 patients (144 toes), with prospective patients reporting subjective results. Patient response to the survey

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Counterpoint

In this side of the debate, the authors share evidence from the literature as well as key aspects of the diagnostic and surgical decision-making process that they feel supports tendon transfer indirect repair as the optimal approach for most plantar plate tears.

By John Martucci, DPM and Lawrence A. DiDomenico, DPM, FACFAS

Surgical intervention for plantar plate injuries includes a variety of incisional approaches, repair techniques, and industry-driven devices. To adequately address a plantar plate injury, one must address the underlying etiology and dysfunction that produces the condition. To provide the ultimate repair, we contend that the foot and ankle surgeon should consider utilizing tendon transfer techniques to repair a plantar plate injury.

The metatarsophalangeal joints have a fibrocartilaginous thickening of the plantar capsules composed of type I collagen. The plate is thickest underneath the metatarsal head (about 2 mm thick) but attenuates at its attachments proximally to the metatarsal neck and plantar fascia and distally to the base of the proximal phalanx. The lateral aspect of the plantar plate is the most commonly attenuated or torn.[1] The plantar plate complex includes a variety of structures such as the interossei tendons, lumbricals, and flexor tendons which provide static and dynamic stability to the metatarsophalangeal joint.

An injury to the plantar plate can be acute or chronic in the active, athletic patient, regular ambulator, or inactive individual. The pathology most commonly impacts older, female patients and is not the result of a single trauma.[2] While one might justify direct repair for an isolated traumatic event, most cases are chronic with additional associated pathologies. In our opinion, balancing the foot around the joint and treating the underlying pathologies of the lower extremity seems to provide the best long-term outcome, with the most predictable and reproducible results compared to a direct repair.

When a patient presents with lesser metatarsophalangeal joint pain (most commonly, the second MTPJ), radiographs should evaluate for a fracture, arthritis, avascular necrosis, and other deformities. Coughlin and colleagues performed a cadaver study that revealed hallux valgus in 88 percent of specimens with a crossover second toe deformity due to excessive loading on the lesser metatarsophalangeal joints.[2] Similarly, other studies emphasize the role of the first ray in lesser metatarsophalangeal joint pathology.[2-4]

In 2011, Mickle and team examined forefoot pressures in patients over 60 years of age and found that those with hallux valgus generated a significantly higher total peak pressure and total pressure-time integral than the control group.[5] More specifically, the hallux valgus group experienced significantly higher peak pressure under the first metatarsal and second metatarsal regions and significantly higher pressure-time integral at the first metatarsal region relative to the control group. Further, those with lesser toe deformities had significantly higher peak pressures under the second and third metatarsals than controls.[5] Finite element modeling also shows that with the development of hallux valgus, stress under the lesser metatarsals increases. This stress concentrates at the distal second and third metatarsals and can damage the joint capsule.[6]

Other studies suggest increased second metatarsal protrusion distance measured on radiographs may correlate with plantar plate injuries. The Weil Foot & Ankle Institute highlights how this "protrusion" of the second metatarsal correlates with plantar plate injury.[7,8] They also noted an increased intermetatarsal angle (greater than 12 degrees) and medial deviation of the second toe was likely to be diagnosed with plantar plate repair as confirmed intra-operatively.[7,8]

Key Diagnostic Concepts

Addressing a plantar plate injury, unless isolated and traumatic, involves more than just addressing the second or lesser metatarsophalangeal joint. A patient's condition may require correcting equinus contracture of the posterior muscle group as well as the instability/hypermobility of the medial column and/or hallux valgus, in an effort to reduce forefoot overload and pressure under the lesser MTPJs.[9-13]

Aside from plain film radiographs, ultrasound and magnetic resonance imaging (MRI) are valuable for evaluating the plantar plate complex and exploring other soft tissue etiologies such as

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was 53.5 percent. The authors identified a well-aligned toe in 87.1 percent of cases, a recurrence rate of 7.6 percent, and revision occurred in 2.8 percent. They found statistically significant improvement in the overall modified Foot Function Index with subscales of pain, disability, and function in the reported preoperative and postoperative states.[6]

In 2020, Fleischer et al identified the challenges surgeons face regarding when to repair the plantar plate.[7] The frequently employed metatarsal osteotomy to address metatarsalgia related to a long metatarsal and achieve restoration of the parabola is not without its risks and complications. The development of a floating toe is a known consequence.[8,9] In their prospective level III study, Fleischer looked at adult subjects with isolated second metatarsal Weil osteotomy and those with osteotomy and direct plantar plate repair.[7] Using the Foot and Ankle Functional Outcome Score and radiographic alignment, patients undergoing osteotomy with plantar plate repair demonstrated significant improvement in preoperative to postoperative Foot and Ankle Outcome Score subscales. They did identify that those undergoing plantar plate repair with the osteotomy typically had higher grade plate tears.[7] Their study suggests that patients would benefit from direct repair of the plantar plate in the performance of an osteotomy regardless of disease state.

In Summary

Understanding the progression of plantar plate injury and difficulty in healing resulting from multiple factors, including intrinsic characteristics of the tissue and extrinsic biomechanical and anatomical anomalies, I have attempted earlier restoration of normal physiologic tension of the failing tissue employing small joint arthroscopy with synovectomy and radiofrequency thermal shrinkage. Supporting this approach was reported outcomes by Nery and colleagues in 2015.[10] Moving beyond surgical reparation, the world of regenerative medicine is gaining increasing knowledge and traction in the regeneration of musculoskeletal disorders. Advancing study and research will likely lead to regeneration of failing connective tissue so that we no longer have to "take from Peter to pay Paul." ■

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space-occupying lesions, tendon pathology, or neuromas that may be pain generators about the second MTPJ.[12] One can typically see damage typically at the proximal phalanx insertion with notable hypoechoic changes. Additionally, enthesophytes may be evident.[1] With ultrasound, one can perform dynamic evaluation, as well. In some cases, we find a tear may only be apparent when the digit is dorsiflexed or stressed in the transverse plane.

MRI is a valuable tool for evaluating the plantar plate and surrounding structures.[14] A normal plantar plate will be hypointense on all sequences but may exhibit some hyperintensity and attenuation near the insertion on the proximal phalanx. These findings may also correspond with marrow edema of the proximal phalanx. The pericapsular fat may show edema and fibrotic change that one should not confuse for a potential neuroma.[1,12]

What Is The Evidence And Rationale For Indirect Repair?

Conservative measures such as activity modification, taping, orthotics, padding, shoe gear changes are insufficient in most cases.[4] Surgically, however, in the authors' opinion, there is no need for bony work. In evaluating a patient with a plantar plate injury, if one looks at the anatomy and radiographs, and the patient has not experienced any previous local trauma or surgery, it has been our observation that there are no deformities noted in the metatarsal or the toe. The metatarsal and phalanges are normal. Most commonly, the MTPJ and phalanges are contracted by deforming forces from the flexor and/or extensor tendons, therefore there is no need for bony intervention for what is a tendinous issue.

The goal of tendon transfer here is to isolate and release the contracture and deforming force while removing abnormal pathologic pressures. The surgeon must evaluate both the extensor and flexor tendons about the MTP joint. If there is an isolated pathological contracture involving the flexor tendons only, then one performs a flexor digitorum longus (FDL) tendon transfer into the extensor hood with a flexor digitorum brevis (FDB) (both medial and lateral attachments) tenotomy/release. This will straighten the toe, decrease deformity and assist with gaining purchase power of the toe on the metatarsal. As a result, one may note increased plantarflexion strength/purchase power of the toe and create stability while restoring anatomic alignment and producing a better lever arm for the intrinsic muscles. In our experience, one may also find increased stability and reduced stress across the plantar plate. Girdlestone is first credited with performing a long and short flexor transfer into the extensor hood. Other authors have modified this technique, and now various approaches exist.[9,15-17]

Commonly there is an extensor contracture component in addition to the flexor contracture associated with the plantar plate injury. In this scenario, an extensor tendon transfer is warranted in combination with a FDL transfer. A modified Hibbs procedure involves extensor digitorum brevis (EDB) and extensor digitorum longus (EDL) tenotomies along with a MTPJ capsulotomy. Following those two tenotomies, one performs a tendon transfer of the most distal aspect of the tenotomized proximal portion of an EDB tendon (smaller/weaker tendon) into the most proximal portion of the distal stump of the EDL tendon (insertion into the toe) with a weave graft. This tendon transfer essentially lengthens and weakens the extensor pathologic force and removes the extensor contracture of the tendons about the MTPJ. It essentially changes the function of the tendons resulting in fundamentally weakening/decreasing the power of the long, large EDL muscle/tendon that plays a significant role in the deforming process. In combination with a FDL tendon transfer, this balances the abnormal forces and provides stability and anatomic alignment by removing all the deforming forces. These tendon transfers are often performed with a posterior muscle lengthening and stabilization of the first ray as this pathology results from a much greater issue than just an isolated deformity.[17]

Thompson and Deland provided a retrospective review of thirteen feet that underwent flexor tendon transfer for second MTPJ instability.[18] All patients presented with second MTPJ pain and a positive vertical stress/drawer test. One patient was "dissatisfied" postoperatively due to stiffness. Eighty-five percent of patients had hallux valgus deformity. Seven patients agreed to concomitant correction. At 4.75 years, a few patients reported some stiffness but no recurrence of deformity or significant pain.[18] In 2012, Iglesias and colleagues performed a meta-analysis that cited a patient satisfaction rate of 91.8 percent for those that had flexor tendon transfers for digital deformities.[19]

Ford and colleagues performed a cadaveric study that suggested that a direct repair of the plantar plate alone produces similar stability to the complex as a flexor tendon transfer. The authors explained that chronic pain and subluxation of the joint may require a flexor tendon transfer for added stability in addition to concomitant procedures such as correction of a hallux valgus deformity.[4]

A Weil distal metatarsal osteotomy is also a popular procedure to gain access and decompress the joint. However, evidence suggests that direct repairs of chronic plantar plate injuries with or without a metatarsal osteotomy may have suboptimal results.[20] A recent review of

144 toes that underwent direct plantar plate repair with or without metatarsal osteotomy found that 55 percent of patients were extremely satisfied, but 38.2 percent were dissatisfied. The study excluded patients who underwent tendon transfers. Lastly, 27.6 percent of toes reportedly did not "touch the ground" when standing. This study provided evidence with variable results after a plantar plate repair without additional soft tissue rebalancing.[20]

Nery and colleagues provided a classification and approach to treatments based on the location of tears.[21] All patients received Weil osteotomies to decompress the joint but had a variety of procedures repairing or stabilizing the plantar joint capsule – from direct repair to flexor tendon transfer. They recommended a tendon transfer in cases with the most damage to the plantar plate. They also highlighted the procedure's ability to combat the hyperextension sequelae a metatarsal osteotomy may produce.[21]

Concluding Thoughts

In conclusion, we contend that an indirect repair, consistent with tendon transfers and balancing the foot, provides a predictable and reproducible result for patients with plantar plate tears. Moreover, indirect repair is less cumbersome than some of the devices currently on the market utilized for a direct repair. Also, we expect that the indirect repair should be far less expensive than devices utilized for a direct repair. A direct repair involves a #15 blade, a K-wire for fixation, and suture.

In the authors' opinion, one must seriously consider the underlying pathology and perform other procedures such as posterior muscle lengthening, stabilizing the first ray, and tendon transfers around the plantar plate injury to balance and create stability to prevent further breakdown of the plantar plate. ■

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