CHAPTER **29**

SECOND METATARSOPHALANGEAL JOINT INSTABILITY: THE TREE IN THE FOREST

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Second metatarsophalangeal (MTP) joint instability is a well recognized entity but remains without a completely definitive solution. The primary pathology is typically a compromised plantar plate that frequently leads to a worsening digital deformity that may in and of itself have contributed to the attrition of the plantar plate originally. Frequently, adjacent digital deformities exist in both the sagittal and transverse planes that impact both the development and correction of the second MTP joint. A greater appreciation of the entire forefoot as a unit and how the metatarsal parabola and length patterns relate to metatarsalgia in general may help us continue to refine our surgical approach to this vexing condition.

There is no pathological entity in the forefoot that has received as much study, discourse, and debate in the last 10 years as the unstable second MTP joint. Emphasis has focused predominantly on confirmatory diagnoses and surgical repair. Unfortunately, a definitive reconstructive procedure or combination of procedures have yet to establish themselves as the gold standard belying the complexity of etiological factors as well as the variability of the patients that suffer this condition.

It is easy to lose sight of the forest on account of one tree and that tree metaphorically being the plantar plate of the second ray. We must consider a more holistic global view of the entire forefoot if we are to more precisely achieve a lasting correction to the deformity that also resists late recurrence or simultaneous recurrence with emerging or early stage adjacent digital pathology. This holisitic view necessarily includes an appreciation of the evolutionary and extrinsic factors that might predispose the second MTP joint plantar plate to suffer tears of attrition over an active lifetime thereby compromising stability of the joint itself.

A logical starting point in appreciation of the condition is those facts we know for certain. Those facts that have not changed in recent history of at least several 1,000 years. Namely the anatomy, the biomechanical function, and how we have arrived at being creatures of upright bipedal terrestrial gait. We know without argument that the MTP joint is comprised of bone and soft tissue and we understand implicitly that in the absence of trauma, iatrogenia, or systemic and congenital disease that the deformities we encounter as foot and ankle surgeons are of the soft tissues. The bones simply assume positional abberance as the sequellae of suprastructural loads and forces exerted on the soft tissues.

The pertinent anatomical structures are the collateral ligaments arising from the medial and lateral aspects of the metatarsal head and blending plantarly with the glenoid like plantar plate that also encompasses the insertional points of the distal plantar fascial attachment, the interossei, and the fibrous expansions of the flexor tendon sheath and deep transverse metatarsal ligament. The plantar plate – plantar fascial apparatus attaches firmly to the base of the proximal phalanx and has no solid endpoint attachment proximally as it is an extension of the plantar fascia. This is critical to understand as its anatomical existence does not allow it to function as a ligament but rather as a passive plantarflexor of the second MTP joint via an intact windlass mechanism in the non-pathlogical foot (1). We understand as well that the second metatarsal is routinely longer than the first and third metatarsals. This may be anatomic or as the result of previous first ray surgery and medial column insufficiency but the result is the same. The adjacent anatomy thereby predisposes the second metatarsal head and by extension the plantar plate to longer and higher loads that eventually cause fatigue, attrition, and failure. These patients predictably develop unstable MTP joints that deviate in the sagittal and or transverse plane.

Deviation of the toe seems simplistically understood but reconsideration of the forces that cause the deviation is important to fully grasp why the condition develops at all. The muscles of the foot are comprised of intrinsics and extrinics. Their job is to act via their tendinous attachments to bones constrained by stable joints of the foot that are such stabilized by intact ligamentous constraints. In essence, since there is no true proximal osseous fixation point for the plantar plate at the metatarsophalangeal joint level and any biomechanical fault can easily predispose the plate to tear and it classically does so at the rim of the base of the proximal phalanx or its most rigid stable fixation point. If the extrinsic muscles or deviators flexor digitorum longus and extensor digitorum longus gain a functional advantage over the intrinsics flexor digitorum brevis and interossei the stabilizers then the plantar plate insufficiency is manifest as either dorsal or tranverse plane subluxation of the digit. An

Figure 1A. A normal foot with no tendency toward hallux valgus.

Figure 1B. The obvious lateral deviation of the great toe and medial deviation of lesser toes.

Figure 2. Clear medial drift of toes 2, 3, with no evidence of any hammertoe deformity and in the absence of any first ray pathology. The first MTP is perfectly congruous and the second and third are congruous yet mildly deviated. This must be purely due to long flexor pull at this stage. The fourth DIP joint is contracted medially as well signifying excessive pull in the FDL tendon.

additional yet underappreciated anatomical fact is that the second ray lacks a plantar interossei thereby making it slightly more susceptible to instability in the dorsal direction as well.

We are, the author believes, predisposed to this condition evolutionarily, which underscores the frequency of the condition and the difficulty in achieving lasting correction. It is difficult to counter nature and even more so to correct nature. That the human foot evolved from arboreal gait and the necessity of an apposable digit to our current upright bipedal terrestrial gait is really without question (2). The first metatarsal is likely really a proximal phalanx in function and the large splay of a metatarsus primus varus deformity correlates completely with the large yet gradually reducing divergence of the first and second rays of earlier primates. The first metatarsal has all the characteristics of a phalanx based on location of growth plate, nutrient foramen and even length/width dimensions and ratios compared to the phalanges of all lesser toes (3). The amount of active plantarflexion available at the great toe joint and lesser MTP joints is also likely a vestigial grasp reflex as it serves no functional purpose except in very specialized activities or sports (4). One may indeed observe that even in a normal foot with no tendency toward hallux valgus that the direction of pull of the FHL tendon is laterally and the FDL tendon is medially (Figure 1).

The predisposition to crossover second toe is completely logical and unsurprising when encountered. We see this evolutionary tendency in patients as well that have early medial drift of the toes in the absence of any hammertoe deformity or sagittal plane instability and even in the absence of any first ray pathology and specifically no deformity of hallux valgus. This might be considered by many clinicians simply a prodromal or predislocation phase of a classic plantar plate instability but it is not that easily explained away as the only extrinsic force that can cause the deviation is the long flexor tendon. Furthemore this can be seen with a completely congruous second MTP joint radiographically signifying that the ligamentous and plantar plates constraints are undisrupted (Figure 2).

With frank disruption of the plantar plate and subluxation of the toe isolated to the second ray, the literature is complete in that surgical reconstruction today will include some consideration and combination of digital arthrodesis, MTP joint release, primary plantar plate repair, and or flexor to extensor transfer and potentially a decompressive metatarsal osteotomy. The merits and preferences of various authors' approaches are within the body of this journal edition. Regardless of the approach, for a lasting correction to be achieved it must not only correct the existing anatomic deficiency but in some fashion alter the biomechanical tendency that caused the planter plate to rupture in the first place. When the instability is due to acute trauma, iatrogenic in nature, or clearly related to faulty first ray mechanics then a direct approach combined with repair of the first ray and hallux valgus is as close to correcting the underlying anatomic deficiency one can get with the techniques available today (Figure 3).

However it has been this author's observation that upon close inspection the vast majority of cases of second MTP joint instability are not isolated and in fact multiple lesser digit instability is just as common and even the norm. The chief complaint of the patient may be the crossover second toe, but the third and fourth toe are routinely drifting as well. Therefore a surgical approach focusing soley on the first two rays will be inadequate. Consistently a decompressive osteotomy is required of not only the second metatarsal but also the third and possibly even the fourth and fifth.

This is where we must step back and broaden our view to include the whole forest. We need to look at the entire forefoot as one unit and seek global harmony of all MTP joints and the metatarsal parabola rather than fixate soley on the second MTP joint even when it is the chief complaint. To not do so invites residual or recurrent deformity and frequently unmasks adjacent joint pathology that went unrecognized in our zest to repair the second. Interestingly my anecdotal and clinical experience has been that the frequent complication of floating toes after Weil osteotomies of single rays is lessened as more harmony is achieved of the entire forefoot parabola with multiple decompressive osteotomies. The floating toe arises from the inherent lack of tension on the plantar fascial stabilizing slip to the base of the toe after shortening osteotomies.

It is my belief that multiple osteotomies and a longitudinal and mediolateral decompression of the entire forefoot allows the plantar fascia and likely the interossei to recontract or adaptively shorten back into a more functional windlass mechanism type effect on the base of the toes. This is intuitively less probable with an isolated second metatarsal Weil osteotomy for example as the other metatarsals remain relatively longer and therefore the distance or tension from plantar fascial origin to insertion remains taut while the isolated second MTP joint slip is lax (Figures 4, 5).

The forest that surrounds the tree of the second ray is the entire forefoot unit that has become biomechanically unstable as a whole and therefore must be addressed as a whole if we wish to gain lasting control over any one ray.

Figure 3A. Preoperative second toe crossover defomity and previous failed hallux abducto valugs surgery.

Figure 3B. Correction via a decompressive Weil second metatarsal osteotomy, PIP joint fusion with absorbable pin and V toY dorsal skinplasty. The residual hallux abducto valgus was also stabilized via a repositional bunion correction and Akin osteotomy. Figure 3C. Deformity correction.

Figure 4. Note the floating second post-Weil osteotomy. The third toe clearly is drifting medially as well and this patient may very well have benefited from second and third MTP joint surgery to more completely harmonize the forefoot.

Figure 5A. Classic crossover toe deformity of second toe.

Figure 5B. Note the medial drift of the third toe as well.

Figure 5C. Effective alignment is achieved on the operating room table by use of Weil decompression osteotomies, V to Y skinplasty, and digital stabilizations via PIP joint fusion. No Kirschner wires are crossing the MTP joints and all toes are neutral in all planes.

Figure 5D. Preoperative view.

Figure 5E. Intraoperative view.

Figure 5F. Radiographic realignment via decompressive weil osteotomies of metatarsals 2 and 3.

Figure 5G.

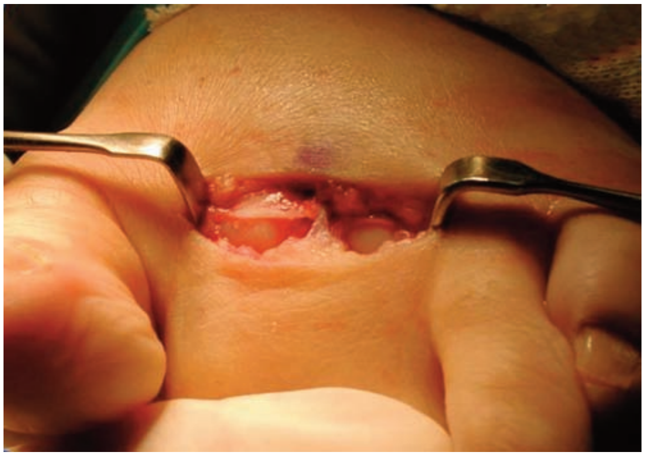

Figure 6A. Adjacent metatarsal osteotomy performed through a dorsal tranverse incision allowing correction simultaneously under direct visualization of all rays.

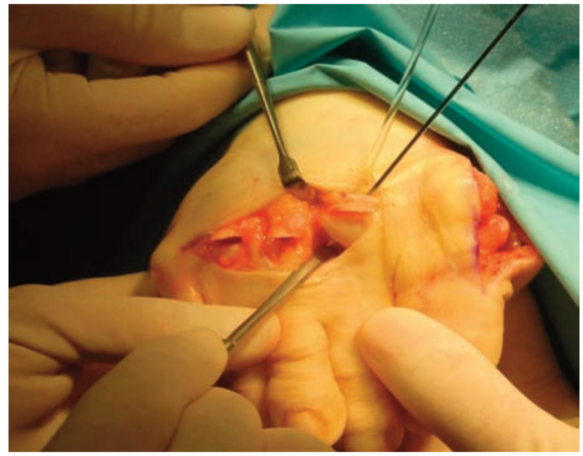

Figure 6B. Adjacent metatarsal osteotomy.

Figure 7. Severe subluxation of all toes in the transverse plane corrected with a Barouk style longitudinal decompression of the entire forefoot via multiple Weil osteotomies. The first ray was addressed via a shortening Scarf first metatarsal osteotomy.

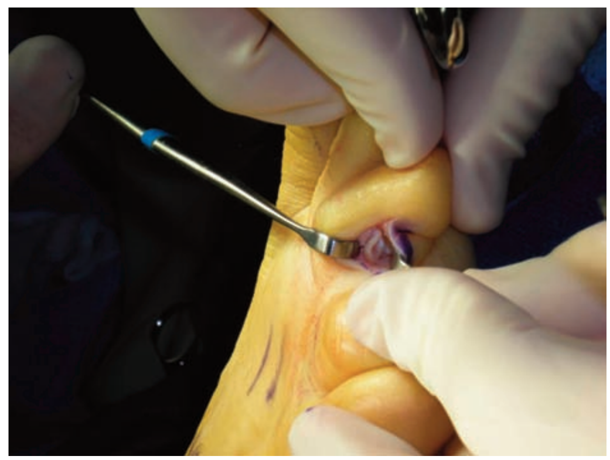

Figure 8. Lateral approach to a passively reducible hammertoe deformity with direct visualization of the long flexor and short flexor tendons.

By the time the toes are drifting in 5 different directions the soft tissues are trying to tell us something. They have become through soft tissue adaptation essentially too short for the foot or phrased differently the bones have become in a sense too long for the soft tissues that surround them. The approach popularized by Louis Barouk of France is to globally decompress the entire forefoot through the use of multiple Weil osteotomies frequently on all 4 lesser metatarsals (5). I have largely adopted this philosophy with the exception of a much less incidence of fifth metatarsal osteotomies. Indeed when seeking to correct an unstable second MTP joint decompressive Weil osteotomies of the second and third are advised and clinical results and toe purchase are frequently better with the inclusion of the fourth metatarsal as well (Figure 6).

The determination of when to perform multiple decompressive Weil osteotomies requires a careful study of the preoperative radiographs. Thorough evaluation of this advanced forefoot derangement is the possible exception to the rule that we treat patients first and the radiographs second. Indeed, the necessity of multiple osteotomies and harmonization of the entire forefoot is predicated off the relationships and length patterns of the adjacent metatarsals on the radiographs. A determination is made radiographically and then combined naturally with the patient's chief complaint and functional desires.

Maestro, Ragusa and Tanaka have studied extensively the average of relative metatarsal lengths emphasising the importance of its assessment preoperatively on standard dorsoplantar weight-bearing radiographs (5, 6). Maestro's determination of the ideal non-problematic metatarsal parabola is relative metatarsal length 1 = 2, 2 > 3 by 4 mm, 3> 4 by 6 mm and 4 > 5 by 12 mm. He further considers the fibular sesamoid as the pivot point of the forefoot in gait and has determined that a line passing from the sesamoid's center and perpendicular to the central axis of the second metatarsal has to pass through the center of the fourth metatarsal. This is referred to as the Maestro line and is used to predict the presence or absence of central metatarsalgia and in a global view of the forefoot the need or lack thereof of multiple Weil osteotomies. If the Maestro line passes through or slightly distal to the center of the fourth metatarsal head, then central metatarsalgia is unlikely (5). On the contrary, a Maestro line passing proximal to the fourth metatarsal head is generally accompanied by remaining metatarsalgia and by extension an unmasking of adjacent MTP joint instability when perhaps only the isolated second MTP joint crossover toe deformity was considered surgically.

We may be guilty of not seeing the forest on account of the one tree. It is likely that a heightened awareness of the relative metatarsal lengths both in preoperative and postoperative assessment will predict more accurately those MTP joints that are unstable already or potentially unstable in the future. It seems intuitive as well that these metatarsal parabola considerations also explain the windswept deformities of toes both medially or laterally that have yet to sublux in the sagittal plane. The transverse plane instability may precede or forebode an impending plantar plate rupture of any ray. Theoretically and by anecdotal clinical experience the global longitudinal decompression of the forefoot allows the intrinsics and plantar fascial attachment to the plantar plate readaptively shorten and a complete "relaxation" of the forefoot osseously, intrinsically and extrinsically is complete (Figure 7).

The last consideration for correction with a crossover toe deformity of any digit is the actual digital pathology itself. The standard operative approach has always been to commence with the toe surgery and perform a step wise approach to hammertoe/clawtoe reduction and as the last step consider the instability at the MTP joint level. I propose a complete reversal of this thought process based on an appreciation of the fact that in these cases the primary pathology is the plantar plate dysfunction and the digital deformity is secondary. Furthermore the hammertoe deformity is frequently able to be reduced or partially reduced and even more so after the longitudinal decompression of the metatarsal length or parabola as a whole. We are all familiar with the appearance of pristine articular cartilage on the head of proximal phalanx that we routinely destroy as we fuse the PIP joint. If we appreciate that the toe deformity is secondary and due to adaptive soft tissue contracture that is now relaxed or decompressed, why not pursue a joint preservation approach to the digital pathology as well. To extend the metaphor, we traditionally have focused on the toe as the tree and the forest may well be the MTP level and entire forefoot as a whole.

Why do not we seek as foot and ankle surgeons when addressing isolated second MTP joint instability or even advanced forefoot deformities to preserve digital length first and decompress metatarsal length primarily? The initial answer is we have been indoctrinated with the unreliability of lesser metatarsal osteotomies and that the most effective means of gaining control over an unstable MTP joint is by fusing a PIP joint and thereby converting the FDL tendon to a plantarflexor of the MTP joint and not a dorsiflexor of the PIP and reverse buckler of the MTP joint. And yet we have all seen for years the vagaries of multiply operated hammertoes drifting unstably in all planes, stiff, rigid, nonpurchasing, and deviated. Is there a better answer to the rote fusion of so many toes?

The Podiatry Institute stepwise approach to hammertoe/clawtoe correction is a reliable and proven effective method for stabilizing digital deformity and reducing plantar pressures beneath the metatarsal heads. However the results may not be lasting except for mild deformities and residual or late drift of the toes in spite of perfect execution of the stepwise approach including pinning across the MTP joints is not unusual at all. In fact I abandoned placing pins across the MTP joint years ago due to dissatisfaction with the late results and postoperative course for the patients. This proposal is a reassessment of the standard stepwise approach and a philosophical reassessment of the order in which we address the unstable second metatarsophalangeal joint and by extension advanced derangement of any of the MTP joints.

The stepwise approach of extensor lengthening, PIP joint fusion or arthroplasty, extensor hood release followed by MTP joint capsulotomy, and the McGlamry elevator to release the plantar plate fails to include an assessment of the functionality of any anatomy on the plantar side of the joint. Routinely the push up test is performed on the metatarsal head between each step and if the toe is still elevated, a pin is advanced across the MTP joint. Here is the first point of divergence in the adjusted thought process. If the toe is still elevated in the sagittal plane after the sequential release and fusion of the toe then there must be an anatomical explanation for why. It must be one of three possibilities: a compromised plantar plate, a dysfunctional flexor tendon, or an abnormal metatarsal length or parabola. Simply pinning the MTP joint for 3 to 6 weeks is not a lasting solution and the toes consistently deviate again over the long term. The traditional stepwise approach is best reserved for only the earliest and most reducible deformities.

A preferred approach in advanced deformity of the forefoot is to address each individual ray as a “junior” first MTP joint and a potentially “junior” bunion. The forefoot is looked at globally and consideration given to the MTP joint surgical work first rather than the digital work. We must consider the forefoot as a whole entity itself and then end up correcting the ray of dominant deformity while blending the assessment of the patient’s chief complaint and functional desires. This is similar to how we routinely correction hallux abducto valgus deformity and at conclusion decide if an Akin osteotomy is required or not. Rather than start surgically with the digital dissection and proceed to the MTP level it makes more biomechanical sense to start with the MTP joint level and proceed to the digital level depending on necessity or not. The deformity at the MTP joint level is addressed through a longitudinal or transverse incision depending on how many rays are to be addressed.

If it as an isolated ray deformity, then a longitudinal incision will suffice. If adjacent ray deformities exist then an interspace longitudinal incision may be used or a dorsal transverse incision to access all MTP joints at the same time (Figure 6). Therefore, attention and surgical procedure at the MTP level where the deformity is corrected with the surgeon’s preference of MTP joint release, medial, and lateral capsulotomy or capsulorraphy, medial or lateral intrinsic release if warranted, a metatarsal osteotomy with decompression and or medial and lateral translation and considerations of primary plate repair or flexor to extensor transfer. Analagous to hallux valgus surgery, the metatarsal head must be shifted back under the base of the proximal phalanx and realigned over the plantar plate. Step 2 then proceeds with careful evaluation of whether any residual hammertoe is passively reducible or not.

This is really an extension of the preoperative examination and a reassessment of the need for a stepwise approach to correct the hammertoe. Many times after the surgical work is performed at the MTP level, enough slack has been created in the long flexor tendons that a PIP fusion or arthroplasty may not be warranted and we may have the attractive option of preserving not only digital length but also a contractable functional toe that frequently has no abnormality of the cartilage of the proximal phalangeal head nor metatarsal head thereby obviating the need for a resection of that cartilage. Either flexor digitorum brevis or longus tenotomies may be selectively performed with or without temporary pinning. These procedures may be performed preferentially through medial or lateral toe incisions that allow release of the tendons without disruption of the dorsal extensor tendon or cartilage of the phalangeal heads (Figure 8). If the toe is still not completely reducible after release of the short flexor tendon slips into the base of the middle phalanx a plantar capsulotomy may be performed at the interphalangeal level. If the toe does not reduce, a traditional PIP joint fusion may still be performed.

The intraoperative goal in the correction of these deformities is distinct. First, all toes must be straight in all planes with no external pins out the tips of the toes. This is easily accomplished with the use of absorbable pins and gently flexed PIP joint fusions that leave all toes purchasing the ground functionally and aesthetically. No external Kirschner wires are required nor desired (Figure 5). Second, no pins should be crossing the MTP joints. Third, previously undamaged articular surfaces should be left intact at the PIP or MTP level and the toes should not require the surgical soft tissue dressing to maintain the alignment. With effective decompression of the MTP joint and judicious use of repair primarily to the affected anatomy on the plantar side of the joint via plate repair or flexor tendon transfer no pin should be necessary to stabilize the MTP joint itself. The ideal solution one day will be a primary plantar plate repair at the base of the proximal phalanx in combination with a decompression osteotomy of the affected metatarsals all through a dorsal approach. Attempts at doing this are underway but in the investigative phase at this time (7).

The unstable second MTP joint is readily diagnosed and recognized as a challenging entity to correct in a lasting way. The myriad biomechanical forces that cause it and quite likely evolutionary forces conspire to make it difficult to predict what combination of procedures will resolve the deformity most effectively. A deeper appreciation of the concepts of global harmonization of the metatarsal parabola and longitudinal decompression of the entire forefoot as a single functional unit may help us more effectively address this condition. Due to the soft tissue contractures that exist the surgeon is encouraged to consider and correct the MTP joint pathology first and then address the digital pathology to neutralize it only at the level of intervention necessary to ensure in turn it does not remain as a deforming force.

It is felt that taking a holistic view of the forefoot as a whole and only then giving consideration to the ray of dominant deformity will enhance a focused approach to correction of the unstable MTP joint. The actual surgical correction then proceeds in an orderly fashion from the MTP joint affected toward the digital deformity rather than in reverse with emphasis on articular preservation as the ideal and joint destruction only as absolutely necessary. It seems less than optimal to embrace a single tree located in a forest earmarked for clearance. Much better to assess the overall terrain first and the parts that make up the whole, second.

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