

# Management of Tarsometatarsal Joint Injuries

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## Abstract

Joint disruptions to the tarsometatarsal (TMT) joint complex, also known as the Lisfranc joint, represent a broad spectrum of pathology from subtle athletic sprains to severe crush injuries. Although injuries to the TMT joint complex are uncommon, when missed, they may lead to pain and dysfunction secondary to posttraumatic arthritis and arch collapse. An understanding of the appropriate anatomy, mechanism, physical examination, and imaging techniques is necessary to diagnose and treat injuries of the TMT joints. Nonsurgical management is indicated in select patients who maintain reduction of the TMT joints under physiologic stress. Successful surgical management of these injuries is predicated on anatomic reduction and stable fixation. Open reduction and internal fixation remains the standard treatment, although primary arthrodesis has emerged as a viable option for certain types of TMT joint injuries.

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The tarsometatarsal (TMT), or Lisfranc, joint complex is composed of the TMT, intertarsal, and proximal intermetatarsal joints.<sup>1</sup> The unique osseous anatomy of the midfoot along with the stout ligamentous support allows effective force transfer from the hindfoot to the forefoot during ambulation. Injuries to the TMT joint complex are rare, accounting for only 0.2% of all fractures, with a reported incidence of 1 per 55,000 persons.<sup>2</sup> When they do occur, TMT injuries represent a broad spectrum of pathology ranging from low-energy, subtle ligamentous disruptions to high-energy crush injuries with associated soft-tissue compromise.

Given the uncommon occurrence of TMT joint disruptions, as well as the potential for subtle presentation and a lack of familiarity with the injury among treating physicians, up to 20% of TMT injuries are missed initially.<sup>3</sup> A high index of suspicion is necessary when evaluating suspected midfoot trauma. Left untreated,

these injuries often result in painful posttraumatic arthritis and arch collapse. Early diagnosis and maintenance of anatomic reduction of the TMT joints are necessary to maximize patient function.

Nevertheless, appropriate initial treatment of TMT injuries is controversial. A variety of techniques have been described for the management of TMT injuries, but rates of posttraumatic arthritis following surgical treatment still range from 27% to 94%.<sup>4,5</sup> Recently, primary arthrodesis of the TMT joints has shown favorable results for certain injury patterns.<sup>6,7</sup> Despite these promising results, the role of arthrodesis in the management of TMT injuries has yet to be clearly defined.

## Anatomy

The combined ligamentous and osseous anatomy of the TMT joint complex is essential for maintenance of the transverse and longitudinal arches of the foot. The TMT joint

complex is composed of the TMT, intertarsal, and proximal intermetatarsal joints.<sup>8</sup> The first, second, and third metatarsals articulate with the medial, middle, and lateral cuneiforms, whereas the fourth and fifth metatarsals articulate with separate facets of the cuboid.

Several unique aspects of the osseous anatomy contribute to the stability of the midfoot. In the coronal plane, the three cuneiforms along with their corresponding metatarsal bases have a trapezoidal configuration, with the middle cuneiform and second metatarsal base serving as the keystone of the transverse or Roman arch<sup>9</sup> (Figure 1). The middle cuneiform is 8 mm proximal to the medial cuneiform and 4 mm proximal relative to the lateral cuneiform, allowing the second metatarsal base to be recessed.<sup>10</sup> This mortise configuration confers additional stability because the second metatarsal has five separate articulations with the adjacent cuneiforms and metatarsals. Anatomic variations of the second TMT joint may predispose certain patients to Lisfranc injuries. Shorter length of the second metatarsal as well as decreased depth of the second TMT mortise have been identified as risk factors for Lisfranc injury.<sup>11,12</sup>

The ligamentous structure of the TMT joint complex can be categorized according to orientation (ie, transverse, oblique, longitudinal) and anatomic location (ie, dorsal, interosseous, plantar).<sup>8</sup> The transverse intermetatarsal ligaments secure the bases of the second through the fifth metatarsals; however, no such ligament exists between the first and

second metatarsals. Instead, a series of dorsal, interosseous, and plantar oblique ligaments secure the medial cuneiform to the recessed second metatarsal to maintain the crucial mortise relationship.<sup>8</sup> Of these, the interosseous ligament is the strongest restraint of the TMT joint complex and is commonly referred to as the Lisfranc ligament<sup>13</sup> (Figure 2). The Lisfranc ligament may have variable anatomy, with both single-bundle and double-bundle variations described.<sup>14</sup>

The plantar oblique ligament, another critical component of the TMT ligamentous complex, divides into deep and superficial bands that insert on the base of the second and third metatarsals, respectively.<sup>10</sup> In general, the plantar ligaments are stronger than the dorsal ligaments, which can have important clinical implications for the pattern of injury.<sup>13,15</sup>

The TMT joint complex is dynamically stabilized by the insertions of the tibialis anterior and peroneus longus tendons. In certain injury patterns, the tibialis anterior tendon becomes entrapped between the medial and middle cuneiforms, precluding reduction. The dorsalis pedis artery and the accompanying deep peroneal nerve cross the TMT joint complex and are consistently located just lateral to the extensor hallucis brevis tendon. The deep peroneal artery dives between the first and second metatarsal bases to form the plantar arch. The artery may be avulsed in more severe injury patterns, leading to dorsal hematoma formation or compartment syndrome.

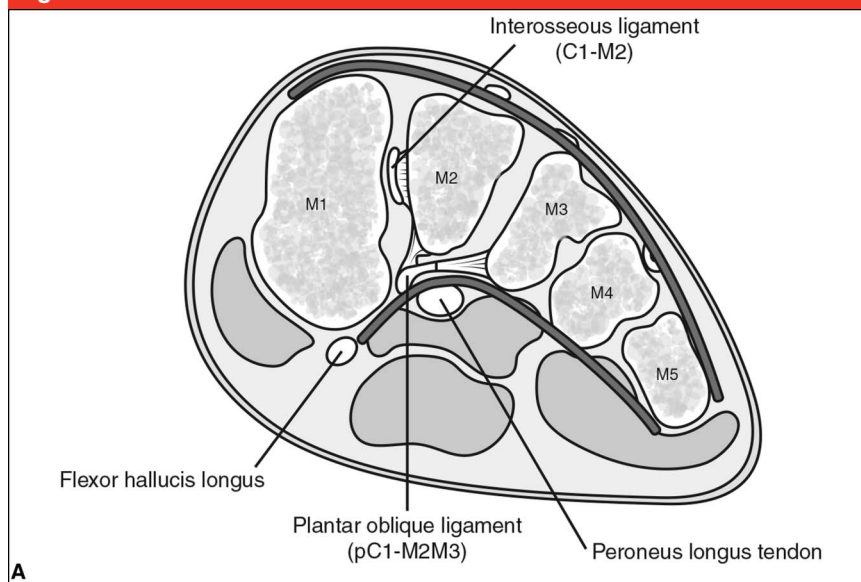
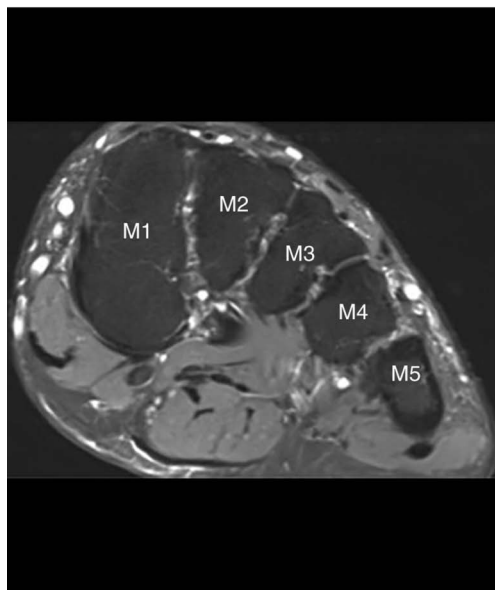
The functional anatomy of the TMT joint complex is best understood by dividing the midfoot into medial, middle, and lateral columns.<sup>1,16</sup> The medial column is composed of the medial cuneiform and first metatarsal, whereas the middle column consists of the middle and lateral cuneiform bones and the second and third metatarsals. Joint motion for the middle column is limited, with a 0.6° arc of sagittal plane motion seen at the second TMT joint.<sup>17</sup> In contrast, the mobile lateral column, which is formed by the fourth and fifth TMT joints, functions as a shock absorber when the foot encounters uneven surfaces. Every effort should be made to maintain the mobility of the fourth and fifth TMT joints. Arthrodesis of the lateral column substantially increases plantar forefoot and calcaneocuboid joint pressure and can compromise treatment outcomes after TMT injuries.<sup>5,18</sup>

## Mechanism of Injury

Injuries to the TMT joint complex can be broadly grouped as direct or indirect mechanisms. Direct injuries typically involve high-energy blunt trauma, oftentimes a crush injury to the dorsal aspect of the foot with substantial soft-tissue disruption. Crush mechanisms commonly involve compartment syndrome and open injuries.<sup>19</sup>

Indirect mechanisms account for most injuries to the TMT complex and are typically seen with an axial and/or rotational force applied to a plantarflexed and stationary foot.<sup>20</sup> Although several mechanisms have

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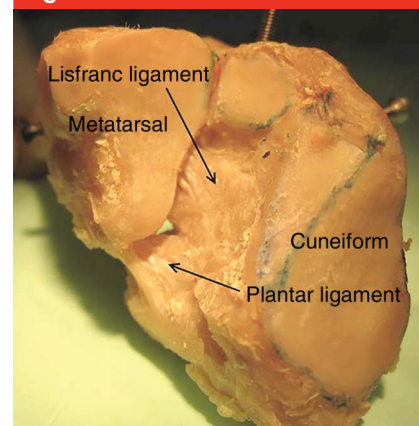
**Figure 1**

**A**

**B**

**C**

**A**, Illustration of the Roman arch architecture of the metatarsal bases with the second metatarsal as the keystone. The interosseous (C1-M2) and plantar oblique ligaments (pC1-M2M3) are shown. **B**, Coronal T2-weighted MRI sequence demonstrating the Roman arch configuration of the metatarsal bases. **C**, Axial long-axis CT cut. The arrow highlights the recessed position of the second metatarsal in the mortise. C1 = medial cuneiform, C3 = lateral cuneiform, M1 = first metatarsal, M2 = second metatarsal, M3 = third metatarsal, M4 = fourth metatarsal, M5 = fifth metatarsal, Nav = navicular, pC1 = plantar medial cuneiform. (Panels B and C reproduced with permission from Siddiqui NA, Galizia MS, Almusa E, Omar IM: Evaluation of the tarsometatarsal joint using conventional radiography, CT, and MR imaging. *Radiographics* 2014;34[2]:514-531.)

been proposed, these injuries vary depending on the position of the foot and the direction of force applied.

The weaker dorsal ligaments typically fail under tension, leading to dorsal displacement of the metatarsals.

**Figure 2**


Photograph of a cadaver specimen demonstrating the orientation of the Lisfranc (ie, interosseous) ligament and the plantar oblique ligament. (Reproduced with permission from Panchbhavi VK, Molina D IV, Villareal J, Curry MC, Andersen CR: Three-dimensional, digital, and gross anatomy of the Lisfranc ligament. *Foot Ankle Int* 2013;34[6]:876-880.)

Abduction or torsional mechanisms may lead to fracture of the second metatarsal base with subsequent lateral displacement of the lesser metatarsals.

Two common mechanisms are theorized to occur in the athletic population.<sup>21</sup> A direct axial force on the hindfoot, with the foot plantar-flexed and the metatarsophalangeal joints in maximal dorsiflexion (ie, as typically observed in a falling player), leads to dorsal tension failure. Abduction injury may occur with the hindfoot fixed and sudden rotation about the midfoot. This mechanism can occur in persons who have the foot anchored in a strap, such as equestrians or windsurfers, or with athletes who suddenly change direction on a planted foot.

## Diagnosis

### Physical Examination

Subtle disruptions of the TMT joint complex are challenging to diagnose.

Figure 3



Clinical photograph demonstrating plantar arch ecchymosis suggestive of Lisfranc injury.

Patients typically have difficulty with weight bearing; in subtle injuries, however, patients may experience pain only during strenuous activity. Swelling is typically located over the dorsomedial midfoot. When present, plantar arch ecchymosis is highly associated with Lisfranc injury<sup>22</sup> (Figure 3). Pain may be reproduced with direct palpation of the TMT joints as well as with passive abduction stress of the midfoot while the transverse tarsal joint is stabilized. Dorsal and plantar translation of the midfoot may reveal subluxation at the level of the TMT joint. In patients who are weight

Figure 4



AP bilateral weight-bearing radiograph of the feet demonstrating lateral subluxation of the second metatarsal base and intercuneiform widening of the right foot.

bearing, symptoms can be elicited during attempts at a single-limb stance on the forefoot.

Although the diagnosis may be obvious in patients with high-energy injuries, careful attention should be directed to the soft-tissue envelope. Closed injuries with fracture blisters signify a substantial soft-tissue insult that may benefit from delayed management or staged fixation.<sup>23</sup> Tense swelling and increasing pain should alert the clinician to the possibility of compartment syndrome.<sup>24</sup>

### Imaging

Lisfranc injuries are commonly missed when diagnosis is based on radiographic imaging. Initial imaging should consist of AP, lateral, and 30°

oblique views of the foot. For visualization of the TMT joints on profile, the AP view should be taken with the x-ray beam 15° off the vertical plane.

Certain radiographic landmarks should be scrutinized on each image to rule out Lisfranc injury. On the AP view, the medial border of the second metatarsal should align with the medial border of the middle cuneiform. On the oblique view, the medial border of the fourth metatarsal and the medial border of the cuboid should be collinear. The lateral view should demonstrate alignment of the dorsal and plantar cortices of the metatarsals with the cuneiforms and the cuboid. Contralateral images should be obtained for comparison with the patient's normal anatomy.

Markers of instability include widening of  $>2$  mm between the first metatarsal-medial cuneiform and the second metatarsal compared with the contralateral side,  $>2$  mm of joint subluxation of the TMT joint, or any dorsal displacement of the metatarsal on the lateral view.<sup>3</sup> An avulsion fracture off the base of the second metatarsal or medial cuneiform, known as the fleck sign, signifies disruption of the Lisfranc ligament.<sup>20</sup>

Signs of instability may not be present on initial radiographs. In patients with suspected midfoot injury, weight-bearing radiographs should be obtained to place physiologic stress on the TMT joint complex. An AP weight-bearing radiograph of both feet on the same cassette is particularly useful for evaluating subtle instability (Figure 4). In patients who are unable to bear weight, a pronation-abduction stress radiograph<sup>25</sup> may be adequate to diagnose instability (Figure 5). In the office setting, stress radiographs may cause major patient discomfort. In patients with a mechanism of injury, examination results, and static images suspicious for TMT joint complex injury, stress views obtained under anesthesia allow appropriate evaluation of midfoot instability.

Advanced imaging can also play a role in the management of TMT joint injuries. CT is useful for delineating areas of articular comminution and nondisplaced fracture lines in high-energy injury patterns. Axial, thin-cut CT slices may also be reformatted in multiple axes to match the coronal, sagittal, and transverse planes of the TMT joint complex.<sup>26</sup> However, CT is not dynamic, and normal osseous relationships may be present in the setting of ligamentous instability. MRI may be particularly valuable in depicting subtle ligamentous injuries with normal radiographic parameters. For example, Raikin et al<sup>27</sup> demonstrated that disruption of the

**Figure 5**



**A**, AP non-weight-bearing radiograph of the foot in a patient with a mechanism and physical examination findings suspicious for Lisfranc injury. **B**, AP stress radiograph during pronation-abduction of the midfoot demonstrating instability, including lateral subluxation of the first and second tarsometatarsal joints.

plantar oblique ligament visible on MRI was highly predictive of intraoperative instability

### Classification

Several classification systems have been proposed for TMT joint injuries. Myerson et al<sup>20</sup> developed the most commonly used system, which incorporates the prior work of Quenu and Guss<sup>28</sup> and Hardcastle et al<sup>29</sup> (Figure 6). The classification scheme divides injuries in terms of joint congruity, location of involvement, and direction of instability. Type A injuries have total joint incongruity. Type B injuries are subdivided into injuries involving the medial column in isolation (ie, B1) and those involving the lateral rays (ie, B2). Type C injuries represent divergent patterns with either partial (ie, C1) or total (ie, C2) incongruity.

Although this classification system does not predict outcome, it provides a framework for understanding patterns of injury, including patterns of instability that may extend to the intercuneiform or naviculocuneiform joints. Importantly, it implies that the energy dissipates in different directions as it enters and exits the midfoot. This is analogous to the tension and compression sides of failure in fracture patterns and may have implications for selection of exposure and type of implant.

Nunley and Vertullo<sup>30</sup> proposed a classification system to guide treatment of low-energy, athletic injury patterns. Injuries are differentiated according to examination, radiographic, and bone scintigraphy findings. Stage I injuries have pain isolated to the TMT joint complex, normal weight-bearing radiographs, and increased uptake on bone scan.

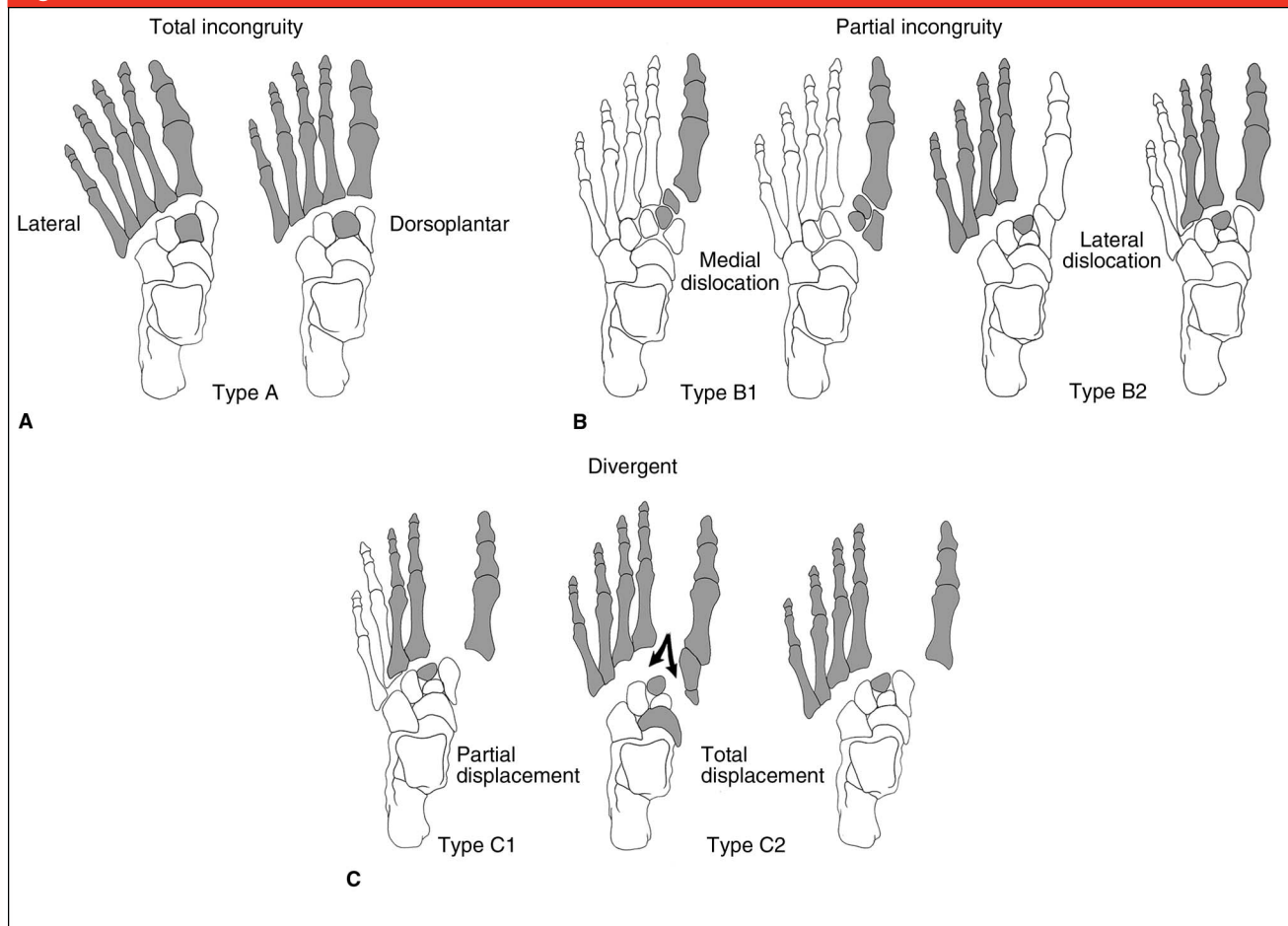
**Figure 6**

Illustration demonstrating the classification of tarsometatarsal joint injuries. The shaded areas represent the injured or displaced portion of the foot. **A**, Type A represents total incongruity, which involves displacement of all five metatarsals with or without fracture at the base of the second metatarsal. The usual displacement is lateral or dorsolateral. These injuries are homolateral. **B**, In type B injuries, one or more articulations remain intact. Type B1 represents partial incongruity with medial dislocation. Type B2 represents partial incongruity with lateral dislocation; the first tarsometatarsal joint may be involved. **C**, Divergent injury pattern, with either partial (C1) or total (C2) displacement. The arrows in C2 represent the forces through the foot leading to a divergent pattern. (Reproduced from Watson TS, Shurnas PS, Denker J: Treatment of Lisfranc joint injury: Current concepts. *J Am Acad Orthop Surg* 2010;18[12]:718-728.)

Stage II injuries demonstrate 1 to 5 mm of widening between the first and second metatarsals on weight-bearing views without evidence of height loss in the longitudinal arch. Stage III injuries have >5 mm of widening of the intermetatarsal space as well as longitudinal arch collapse.

Although these classification systems provide a common descriptive language, none has been useful in predicting outcomes following Lisfranc injury.

## Management

### Nonsurgical

Nonsurgical management of TMT joint complex trauma is reserved for patients who have a stable injury pattern or are unable to tolerate surgical intervention. The key to successful nonsurgical management of Lisfranc injuries is to rule out subtle instability. Midfoot injuries suspicious for instability by history and physical

examination but showing normal results on weight-bearing radiographs should either be followed closely with serial examinations and imaging or be further evaluated with advanced imaging. When a high index of suspicion remains with equivocal findings on advanced images, an examination under anesthesia should be performed. Patients should be counseled and should provide consent for surgical fixation if the examination demonstrates instability.

In patients with stable injury patterns, treatment consists of non-weight-bearing immobilization in a CAM boot or short leg cast for 4 to 6 weeks. Once the immobilization has been removed, patients can progress to weight bearing with a full-length arch support orthotic as tolerated. A course of physical therapy focusing on gait and balance can expedite recovery. Return to function and resolution of pain and swelling may take 4 to 6 months.

### Initial Surgical Management

Surgical intervention is indicated when there is evidence of instability of the TMT joint complex. Most injuries are initially managed with splint immobilization until soft-tissue swelling resolves. Midfoot dislocations require a closed reduction to minimize soft-tissue compromise. When left unreduced, these injuries can lead to continued soft-tissue damage and even full-thickness skin necrosis. Certain high-energy injury patterns may require a staged approach.<sup>23</sup> Provisional reduction using Kirschner wires and/or an external fixator can maintain alignment and facilitate soft-tissue management until definitive fixation can be achieved (Figure 7).

### Definitive Surgical Management

The goal of surgical treatment is to restore the functional anatomy of the foot. However, definitive management is delayed until the soft-tissue envelope is appropriate for open approaches and the pattern of instability and involved joints is clearly understood. Rigid fixation is used to recreate the stability of the medial and middle columns, whereas flexible temporary fixation is used for the mobile lateral column. If relative ankle equinus is not addressed, it can lead to increased loading of the mid-foot and theoretically to failure of

**Figure 7**



Clinical photograph of a patient with a high-energy fracture-dislocation following biplanar external fixation. The reduction did not remain closed, and the soft tissues were not amenable to definitive fixation. (Courtesy of Robert Marsh, DO, Tulsa, OK.)

**Figure 8**

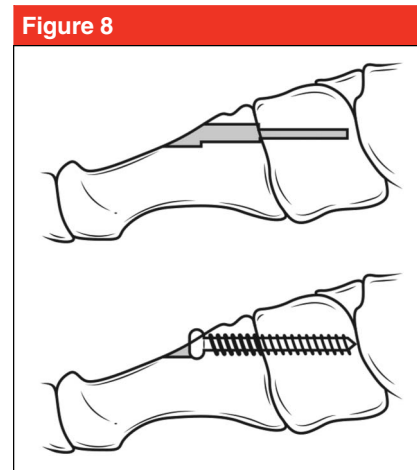


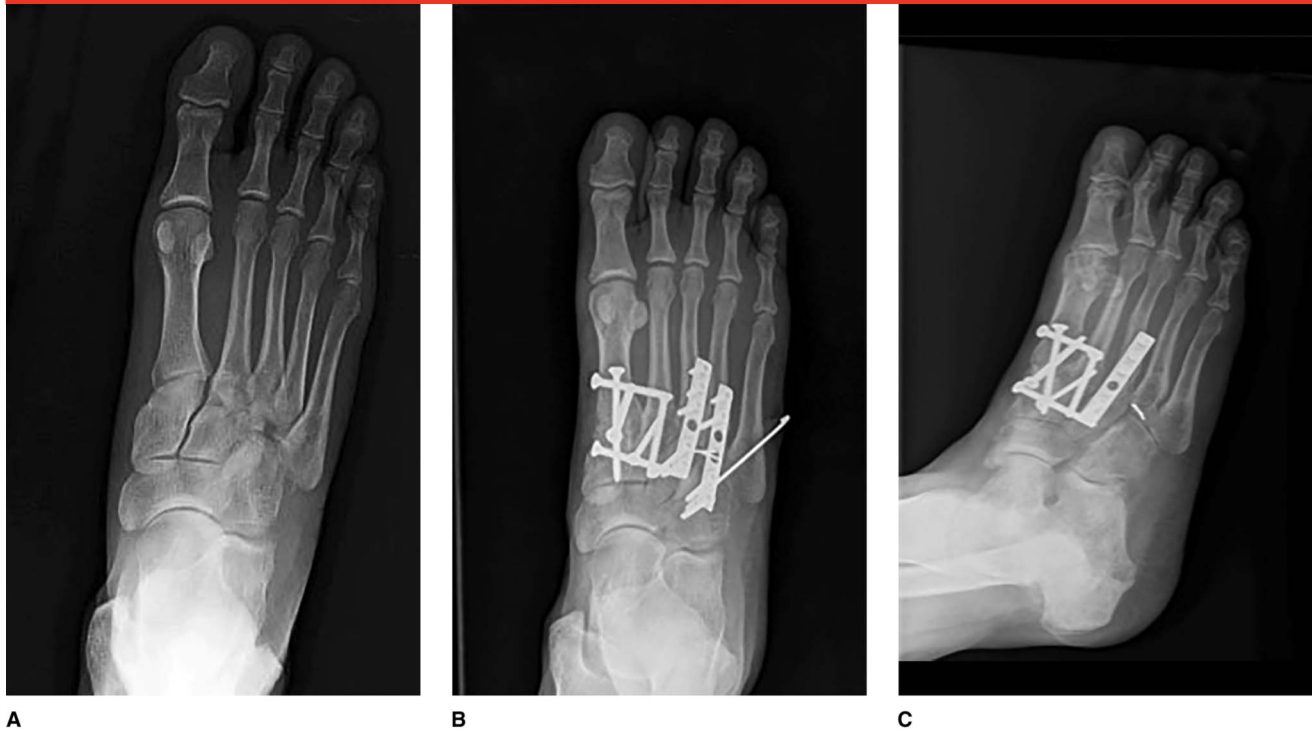
Illustration of lateral views of the first tarsometatarsal joint demonstrating a burred trough in the dorsal cortex of the first metatarsal. This allows retrograde screw placement across the tarsometatarsal joint perpendicular to the joint, minimizes screw head prominence, and prevents breakage in the dorsal cortex.)

fixation. We routinely assess for equinus contracture while the patient is under anesthesia and perform a gastrocnemius recession when a major contracture is found.<sup>31</sup>

Exposure, reduction, and fixation generally proceed from proximal to distal and from medial to lateral. Careful attention should be paid to the intercuneiform joint for signs of instability. We directly visualize the dorsal ligaments of the intercuneiform joint for evidence of injury. When the evidence is unclear, we perform dorsal-plantar translation and axial loading across the first ray to identify occult intercuneiform instability. For three-column injuries, a two-incision dorsal approach is necessary to adequately visualize the involved joints. The dorsal-medial incision, centered between the first and second rays, can help visualize the first TMT joint and the medial aspect of the second TMT joint. This incision can be carried proximally as

needed to address instability or associated fractures of the cuneiforms or navicular bone. Branches of the superficial peroneal nerve cross the extensor hallucis longus in the proximal portion of this incision and are easily injured if not protected. The dorsalis pedis artery and vein and deep peroneal nerve are mobilized laterally and are protected. The interval between the extensor hallucis longus and extensor hallucis brevis is commonly exploited; however, several intervals can be used to expose the affected joints.<sup>32</sup> The dorsal-lateral incision is centered over the fourth metatarsal and can help visualize the lateral aspect of the second TMT joint, as well as the third and fourth TMT joints. The common extensor tendons are mobilized medially, and the muscle belly of the extensor digitorum brevis is split in line with its fibers to gain exposure of the affected joints.

Once adequate exposure has been obtained, anatomic reduction is

**Figure 9**

**A**, Preoperative AP radiograph of a foot demonstrating a Lisfranc injury with major impaction of the articular surface of the fourth metatarsal base. **B**, Postoperative AP radiograph of the same foot. Dorsal plating was used for the comminuted third and fourth metatarsal base fractures. Arthrodesis was performed for the first, second, and third tarsometatarsal joints. **C**, AP weight-bearing radiograph of the same foot obtained after the patient had the fourth tarsometatarsal bridge plate removed at 3 months postoperatively.

achieved under direct visualization and is provisionally held with multiple Kirschner wires. At this point, the surgeon may proceed with either internal fixation or primary arthrodesis on the basis of the injury pattern and surgeon preference. Reduction typically begins with assessment of the intercuneiform joint. If left unaddressed, intercuneiform instability can lead to continued pain and recurrence of deformity. When occult instability is a concern, we recommend rigid fixation across the intercuneiform joint. Reduction of the first TMT joint is then performed according to the alignment of the dorsal and plantar cortices with the corresponding medial cuneiform. Reduction of the first metatarsal base allows appropriate placement of the second metatarsal base into the mortise.

A variety of implants are available for fixation; however, most ligamentous injuries can be adequately stabilized with solid or cannulated small fragment cortical screws. When retrograde lag screws are placed across the TMT joints, making a trough in the dorsal cortex of the metatarsal can be helpful (Figure 8). This allows screw placement perpendicular to the TMT joint and prevents screw breakage in the dorsal cortex. Injury patterns with metatarsal base fractures may require adjunctive plate fixation (Figure 9). When arthrodesis is performed, autograft cancellous bone can be placed at the junction of the fusion sites. This forms a rapid spot weld that relieves shear strain across the fixation.

Certain injury patterns can cause substantial impaction of the

cuboid.<sup>33</sup> These injuries require restoration of lateral column length. Contralateral foot radiographs aid the orthopaedic surgeon in determining the patient's anatomic lateral column length. Although simple fractures may be treated with open reduction and internal fixation (ORIF) of the cuboid in isolation, many of these injuries require adjunctive bone grafting of the cuboid and spanning internal or external fixation (Figure 10). Spanning fixation is typically removed at 8 to 12 weeks to mobilize the fourth and fifth TMT joints.

Patients should be counseled that recovery can take up to 1 year after surgery. Postoperatively, the limb is immobilized in a well-padded splint, which is then converted to a short leg non-weight-bearing cast for 8

weeks. The patient is transitioned to a walking boot at 8 weeks with progressive weight bearing to tolerance. Most patients return to supportive shoe wear with use of an arch support by 3 months after surgery. Once the patient is weight bearing, physical therapy focusing on gait and edema control is initiated.

## Controversies and Future Direction

### Joint-sparing Fixation

Transarticular screws are routinely used for fixation of the TMT joint complex; however, there is concern that drilling and placement of screws across the articular surface increases rates of posttraumatic arthritis seen with these injuries. Joint-sparing fixation techniques, including suture button constructs and dorsal spanning plates, have been explored as alternatives to transarticular screw fixation.

Flexible fixation is an intriguing alternative to standard screw fixation because it allows some physiologic motion but does not violate the articular surface or require a second surgery for implant removal. Recent biomechanical studies in a cadaver injury model demonstrated equivalent stability with suture button devices compared with screw fixation.<sup>34-36</sup> However, suture button constructs may not adequately control multiplanar instability patterns; in these situations, standard techniques or hybrid constructs with both flexible and rigid fixation are advisable.

Spanning plate fixation of the TMT joints provides rigidity while preserving the articular surface (Figure 11). In a cadaver model of a ligamentous Lisfranc injury, dorsal plate fixation was biomechanically equivalent to transarticular screw fixation.<sup>37</sup> Direct clinical comparison of dorsal plate fixation with

transarticular screw fixation is lacking; however, comparable rates of complications and functional outcomes have been demonstrated in a small study.<sup>38</sup>

### Open Reduction and Internal Fixation Versus Arthrodesis

Perhaps the most relevant controversy in the management of TMT joint complex injuries is whether to proceed with ORIF or with primary arthrodesis. The broad spectrum of Lisfranc injury patterns and the variety of treatments available further complicate decision making.

Modern series examining the outcomes of ORIF for TMT injuries found overall favorable results; however, a relatively high rate of posttraumatic arthritis occurred despite appropriate reduction. Kuo et al<sup>39</sup> examined the outcomes of 48 patients following ORIF of TMT injuries at a mean follow-up of 52 months. The overall rate of posttraumatic arthritis was 25%, with both arthritis and American Orthopaedic Foot & Ankle Society mid-foot scores significantly correlated with the quality of the reduction,  $P = 0.004$  and  $P = 0.05$ , respectively. The authors also found a trend toward increased arthritis in patients with purely ligamentous injuries (40%) despite anatomic reduction and suggested that this population may benefit from primary arthrodesis. In contrast, Abbasian et al<sup>40</sup> found no substantial difference in functional outcome, pain, return to activity, or rates of posttraumatic arthritis following ORIF in matched cohorts of 29 patients each with ligamentous injuries or osseous injury patterns. Radiographic arthritis was seen in 27% of ligamentous injuries compared with 31% of osseous injuries; however, only one patient in each treatment group (3%) required conversion to arthrodesis during the study period. The authors theo-

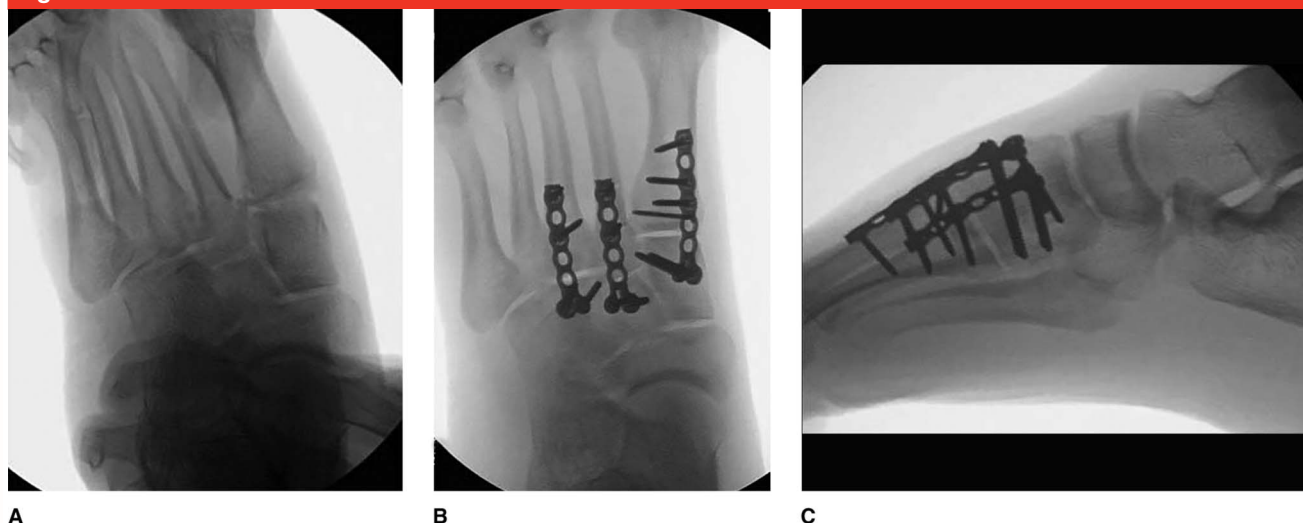
Figure 10



Oblique radiograph demonstrating open reduction and internal fixation of the cuboid with the use of a bridge plate from the calcaneus to the fourth metatarsal to maintain lateral column length. (Courtesy of Jason Nascone, MD, Baltimore, MD.)

rized that the postoperative protocol of prolonged non-weight-bearing immobilization (ie, for 3 months) and use of an arch support following initiation of weight bearing contributed to improvements in the ligamentous cohort.

Two randomized studies directly compared the results of primary arthrodesis with those of ORIF for TMT joint complex injuries. Ly and Coetzee<sup>6</sup> randomly assigned 41 patients to either open reduction or primary arthrodesis for ligamentous injury patterns. The arthrodesis group had substantially improved functional outcomes, higher returns to preinjury activity levels, lower rates of revision surgery, and less pain at final follow-up. In the group

**Figure 11**

**A**, AP stress fluoroscopic image demonstrating instability across the first tarsometatarsal joint and second and third metatarsal base fractures. AP (**B**) and lateral (**C**) fluoroscopic images of the foot after a joint-sparing technique was performed with dorsal bridge plating of the first, second, and third tarsometatarsal joints.

that underwent open reduction, 25% of patients required conversion to arthrodesis for symptomatic posttraumatic arthritis. Routine removal of transarticular screws was not performed in the ORIF group; however, 16 of 21 patients had screw removal during the study period at an average of 6.75 months postoperatively. Results in the ORIF group may have been compromised because permanent or prolonged transarticular fixation can lead to painful arthrofibrosis of the affected joints.

Henning et al<sup>41</sup> found no substantial difference in either the Short Musculoskeletal Function Assessment or Medical Outcomes 36-Item Short Form scores at 2-year follow-up in patients undergoing arthrodesis versus ORIF for both ligamentous and combined injury patterns. There was a substantially higher rate of secondary surgery in the ORIF group; however, most revision surgeries were for elective implant removal as part of the study protocol.

Although both studies reported slight advantages for arthrodesis in terms of functional outcome and

revision surgery, neither review was able to definitively demonstrate the superiority of one technique over the other. More recent systematic reviews have highlighted the need for further high-quality randomized studies comparing the two techniques.<sup>4,42</sup>

### Summary

TMT joint complex injuries are uncommon and are frequently missed. A high index of suspicion is necessary when evaluating suspected midfoot trauma because missed injuries may result in a painful, dysfunctional foot. Nonsurgical management is successful in select stable injuries. When surgery is indicated, anatomic reduction and stable fixation are necessary to restore the functional anatomy of the foot and maximize patient outcomes.

ORIF remains the standard treatment of unstable or displaced injuries to the TMT joint complex. However, posttraumatic arthritis can occur despite appropriate reduction and fixation. Although ligamentous injuries have benefited from partial

arthrodesis, the role of this technique in managing all TMT joint complex injuries has not been determined. Further studies are needed to clarify which injury patterns will benefit from primary arthrodesis.

### References

*Evidence-based Medicine:* Levels of evidence are described in the table of contents. In this article, references 6 and 41 are level I studies. References 4, 19, 27, and 42 are level II studies. References 5, 7, 11, 12, and 40 are level III studies. References 2, 20, 22, 23, 29-33, 36, 38, and 39 are level IV studies. Reference 28 is level V expert opinion.

References printed in **bold type** are those published within the past 5 years.

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