

Lisfranc injury

Anatomy & Pathophysiology

BONY ANATOMY

- The tarsometatarsal (TMT) joint complex forms the distal limit between the tarsal and metatarsal units [1].
- The osseous tarsal complex comprises the navicular, cuboid, and three cuneiform bones [1].
- The second metatarsal is recognized as the keystone of the osseous scaffold due to its positioning between the medial and lateral cuneiforms [1].
- The second metatarsal base fits into a mortise formed by the proximally recessed middle cuneiform [9, 10].
- In the coronal plane, the second metatarsal base serves as the cornerstone in a Roman arch configuration [9, 10].
- The cuboid is the keystone of the lateral column, articulating with the calcaneus and bases of the fourth and fifth metatarsals in the axial plane [1].
- The navicular forms the key in the medial column [1].
- The TMT joint complex is described as a three-column system: medial (first TMT joint), intermediate (second/third TMT joints), and lateral (fourth/fifth TMT joints) [1, 2].
- The cuneiform bones are part of the transverse arch, which acts as a niche for plantar musculotendinous and neurovascular structures [1].
- The longitudinal arch is a dorso-convex bow spanning from the head of the metatarsals to the calcaneus [1].
- The dorsoplantar joint diameter of the first TMT joint is approximately 3 cm [1].
- Biomechanical analysis demonstrates significant motion in both the first and fifth TMT joints [1].
- The lateral column has approximately three times the mobility of the medial column [12].
- Within the medial column, the first ray is three times more mobile than the second or third rays [12].
- The midfoot acts as a stout connection between the forefoot and hindfoot and serves an important shock-absorbing function [4, 5].
- The Chopart and Lisfranc joints are of greater functional importance than the articulations among the midfoot bones [4, 5].

LIGAMENTOUS ANATOMY

- The TMT joint line is stabilized by dorsal and plantar ligamentous connections, creating an amphiarthrotic interface [1].
- The “Lisfranc ligament bundle” spans from the first cuneiform to the second metatarsal [1].
- The pC1-M2M3 ligament connects the plantar aspect of the medial cuneiform to the bases of the second and third metatarsals [1].
- Load to failure and stiffness are more than two times greater for the Lisfranc ligament than for the dorsal ligament connecting the medial cuneiform and base of the second metatarsal [1].
- The dorsal ligament has a lower load to failure, which is related to the more commonly found dorsal displacement [1].
- There is no direct ligamentous attachment between the first and second metatarsals [2, 6, 9, 10].
- Stability between the first and second metatarsals depends on the recessed base of the second metatarsal, the Roman arch wedged shape of the midfoot bones, and the Lisfranc ligament [6].
- The Lisfranc ligament is 8 to 10 mm wide and 5 to 6 mm thick [9, 10].
- The interosseous component of the Lisfranc ligament is the stiffest and strongest [9, 10].
- The dorsal component of the Lisfranc ligament is the weakest [9, 10].
- The plantar component of the Lisfranc ligament inserts on the bases of the second and third metatarsals [9, 10].
- The plantar Lisfranc ligament is known to be the strongest and most important ligament in this region of the foot [11].
- The longitudinal arch is stabilized by the plantar aponeurosis, the long plantar ligament, and the peroneus longus tendon [1].

PATHOPHYSIOLOGY & MECHANISM

- Acute injuries to the TMT or Lisfranc joint account for 0.1% to 0.4% of all fractures and dislocations [1].
- The annual incidence of tarsometatarsal joint injury is approximately 1 in 60,000 [12].
- Motor vehicle crashes account for almost half of TMT injuries [12].
- The typical mechanism of injury involves abduction and direct axial impact to the forefoot while in an equinus position [11].
- Indirect forces involve axial loading or twisting on a plantarflexed foot [6].
- Direct injury occurs when a load is applied to the midfoot [6].
- An indirect injury mechanism involves an impact load applied with the foot in a tiptoe position, resulting in acute plantar flexion at the tarsometatarsal level [19].
- A direct compression injury mechanism involves heel-to-toe compression while kneeling, which may result in lateral displacement of the second through fourth metatarsals [19].
- A third mechanism involves a fall backward from a fixed forefoot, with the heel acting as a fulcrum [19].

- In children, the most common mechanism of injury is a fall from a height (56%), followed by a fall backward (22%) and heel-to-toe compression (18%) [19].
- Insufficient treatment of TMT injuries can lead to painful secondary deformity and impaired function [1].
- Nonoperative treatment has been linked to an increased incidence of secondary displacement and inferior functional outcome [1].
- Nonsurgical treatment in the setting of instability is associated with poor outcomes, with up to 30% developing arthritis over time [11].
- Long-term symptomatic osteoarthritis develops in approximately half of patients with TMT injuries [12].
- Risk factors for the development of osteoarthritis include failure to achieve an anatomic reduction, divergent patterns of TMT incongruence, and a history of smoking [12].
- Predisposing factors for Lisfranc injury include a ratio of second metatarsal length to foot length of less than 29% and a greater second metatarsal length relative to the depth of the mortise formed by the cuneiforms [6].
- The osseous components of the Lisfranc complex are subjected to compressive stresses during load, resulting in a characteristic spongy architecture [1].

CLINICAL PRESENTATION & DIAGNOSIS

- Missed or overlooked TMT injuries are common, with isolated pure ligamentous TMT instability misdiagnosed in up to 20% of cases [1].
- As many as 20% of Lisfranc injuries are misdiagnosed or overlooked [3, 11].
- One study estimates that nearly 25% of Lisfranc injuries are missed or occult on initial radiographs [8].
- Patients with TMT injuries often present with pain in the foot and dorsal swelling, which may be localized over the dorsum of the tarsometatarsal joint [3].
- Plantar ecchymosis on the midfoot implies trauma to the tarsometatarsal ligaments and is pathognomonic for midfoot injury [3, 11, 12].
- Pain on attempted weight bearing or persistent inability to bear weight despite a normal physical examination and radiographs should raise suspicion of a tarsometatarsal injury [3].
- Passive pronation and abduction elicit increased pain in patients with Lisfranc injuries [11].
- A gross deformity may be visible with midfoot abduction and loss of the transverse arch [11].
- Injury to the deep peroneal nerve and artery may occur, requiring careful neurovascular examination [11].
- Compartment syndrome of the foot may occur in high-energy cases [11, 12].
- Crush injuries have a particularly strong relationship with foot compartment syndrome [12].
- Type C divergent injuries are generally high-energy, associated with significant swelling, and prone to complications, especially compartment syndrome [2].

CLASSIFICATION

- Myerson's modification of the original classification of Quénu and Küss and Hardcastle et al. incorporates more proximal injuries to the medial column [2].
- Type A injuries involve displacement of all five metatarsals with or without fracture of the base of the second metatarsal, referred to as homolateral [2, 13].
- Type B injuries involve one or more articulations remaining intact, with either medial (B1) or lateral (B2) displacement [2, 13].
- Type C injuries are divergent injuries that can be partial (C1) or complete (C2) [2, 13].
- In adults, the incidence of Type A, B, and C Lisfranc injuries is 17%, 72%, and 10%, respectively [13].
- In children, Type A and C patterns are extremely rare, and Type B injuries usually demonstrate minimal displacement [13].
- The classification is useful for communication between orthopaedists and determining the plane of displacement and magnitude of soft-tissue injury, but it is not prognostic for the result [2].
- A 2002 classification system for athletes ranges from Stage I (no displacement) to Stage III (first to second metatarsal diastasis >5 mm and loss of arch) [6].

Classification

GENERAL PRINCIPLES

- Classification of Lisfranc injuries is useful for communication between orthopaedists and for determining the plane of displacement and magnitude of soft-tissue injury [2].
- The classification of Lisfranc injuries is not prognostic for the result [2].
- Myerson's modification of the original classification of Quénu and Küss and Hardcastle et al. is presented because it incorporates more proximal injuries to the medial column of the foot [2].
- Subtle injuries through the intercuneiform region and the naviculocuneiform joint are probably more common than previously thought [2].
- The three-part classification of Hardcastle and colleagues, a modification of the original description by Quenu and Kuss, best defines these fractures, their mechanism, and their treatment [13].

TYPE A INJURIES

- Type A injuries involve displacement of all five metatarsals with or without fracture of the base of the second metatarsal [2].
- In Type A injuries, the usual displacement is lateral or dorsolateral, and the metatarsals move as a unit [2].
- Type A injuries are referred to as homolateral [2].
- Type A injuries are characterized by total incongruity of the entire tarsometatarsal joint occurring in a single plane with lateral displacement [13].

TYPE B INJURIES

- Type B injuries involve one or more articulations remaining intact [2].
- Type B1 injuries are medially displaced and sometimes involve the intercuneiform or naviculocuneiform joint [2].
- Type B2 injuries are laterally displaced and may involve the first metatarsal-cuneiform joint [2].
- Type B injuries are characterized by partial incongruity of the joint, affecting either the medial or lateral aspect of the foot [13].
- In Type B medial dislocation, displacement of the first metatarsal from the first cuneiform occurs due to disruption of the Lisfranc ligament or a fracture at the base of the metatarsal which remains attached to the ligament [13].

TYPE C INJURIES

- Type C injuries generally are high-energy injuries associated with significant swelling and are prone to complications, especially compartment syndrome [2].
- Type C injuries involve a divergent pattern where the first metatarsal is displaced medially while any combination of the lateral four metatarsals is displaced laterally [13].

EPIDEMIOLOGY AND PEDIATRIC PATTERNS

- In children, Type A and C Lisfranc injury patterns are extremely rare [13].
- In children, the Type B Lisfranc injury pattern usually demonstrates minimal displacement [13].

LIGAMENTOUS INJURY CLASSIFICATION (ATHLETES)

- A classification system described in a 2002 study has been found to be useful in treating athletes with a relatively mild Lisfranc injury [6].
- Stage I ligamentous Lisfranc injury is defined by the patient being unable to participate in sports because of pain in the Lisfranc joint, with weight-bearing radiographs showing no displacement and bone scan or MRI findings possibly being negative [6].
- Stage II ligamentous Lisfranc injury is defined by first to second metatarsal diastases of 1 to 5 mm but no evidence of loss of arch on weight-bearing radiographs [6].
- Stage III ligamentous Lisfranc injury is defined by first to second metatarsal diastases of more than 5 mm and evidence of loss of arch on weight-bearing radiographs [6].
- The common radiographic appearance of Lisfranc malalignment can be classified as transverse or longitudinal, depending on whether the Lisfranc ligament is torn and whether the pathology extends horizontally across the MTP joints or vertically into the intercuneiform space and perhaps through the naviculocuneiform joint [6].

Clinical Presentation

EPIDEMIOLOGY AND DIAGNOSTIC CHALLENGES

- Acute injuries to the tarsometatarsal (TMT) or Lisfranc joint account for 0.1% to 0.4% of all fractures and dislocations [1].
- Missed or overlooked Lisfranc injuries are common despite improvements in diagnosis [1].
- Isolated pure ligamentous TMT instability is misdiagnosed in up to 20% of cases [1].
- A high index of suspicion is required for the diagnosis of TMT joint injuries because they are often misdiagnosed [6].
- Ligamentous injuries with minimal displacement are likely to be missed, whereas severe injuries with displacement usually present obvious clinical signs [6].

SYMPTOMS AND PHYSICAL EXAMINATION

- Patients with Lisfranc injuries present with pain in the foot and dorsal swelling [3].
- Dorsal swelling may be localized over the dorsum of the tarsometatarsal joint or involve the entire dorsum of the foot in cases of significant trauma [3].
- Pain on attempted weight bearing or persistent inability to bear weight, even with a normal physical examination and radiographs, should raise suspicion for a tarsometatarsal injury [3].
- Ecchymosis on the plantar aspect of the midfoot implies trauma to the tarsometatarsal ligaments and injury to that joint [3].
- Pain with weight bearing accompanied by local swelling and tenderness at the midfoot is the first sign of a Lisfranc injury [6].
- Athletes with mild Lisfranc injuries have difficulty pushing off [6].
- Pronation-abduction or supination-adduction stress is often painful in patients with Lisfranc injuries [6].
- Physical examination for severe Lisfranc fracture-dislocations should include evaluation of the dorsalis pedis pulse, deep peroneal nerve function, and assessment for foot compartment syndrome [6].
- Deformity of the foot is rare in children because most pediatric Lisfranc injuries are not displaced at the time of injury or reduce spontaneously [3].

RADIOGRAPHIC FINDINGS

- Diastasis of the first and second metatarsal bones is a radiographic finding indicative of midfoot injury [6].
- First and second cuneiform diastasis is a radiographic finding indicative of midfoot injury [6].
- Widening between the second and third metatarsals is a radiographic finding indicative of midfoot injury [6].
- Widening between the middle and lateral cuneiforms is a radiographic finding indicative of midfoot injury [6].

- An avulsion fracture at the base of the second metatarsal, known as the fleck sign, represents Lisfranc ligament avulsion and is indicative of midfoot injury [6].
- Malalignment of tarsometatarsal joints on lateral images is a radiographic finding indicative of midfoot injury [6].
- Malalignment of the second metatarsal medial border to align with the medial border of the middle cuneiform is a radiographic finding indicative of midfoot injury [6].
- Malalignment of the fourth metatarsal medial border to align with the medial edge of the cuboid is a radiographic finding indicative of midfoot injury [6].
- Loss of congruity of metatarsal bases is a radiographic finding indicative of midfoot injury [6].
- Compression fracture of the lateral edge of the cuboid is a radiographic finding indicative of midfoot injury [6].
- Comparison with a weight-bearing AP radiograph of the uninjured foot is often helpful in diagnosing Lisfranc injuries [6].
- Stress radiographs taken with the patient under anesthesia may be helpful if routine radiographs are not diagnostic in a mild injury [6].

ADVANCED IMAGING

- CT or MRI is useful if a Lisfranc injury is suspected and plain radiographs are not diagnostic [6].
- CT may be required to define fracture fragments and articular congruity in midfoot injuries [4].
- Weight-bearing or stress views can help ascertain midfoot stability if there is clinical concern [4].

PREDISPOSING FACTORS

- A ratio of second metatarsal length to foot length of less than 29% is a predisposing factor for Lisfranc injury [6].
- A greater second metatarsal length relative to the depth of the mortise formed by the cuneiforms is a predisposing factor for Lisfranc injury [6].

Investigations

CLINICAL PRESENTATION AND PHYSICAL EXAMINATION

- The diagnosis of Lisfranc injuries is notoriously difficult, with as many as 20% of injuries being misdiagnosed or overlooked [3].
- Patients with Lisfranc injuries present with substantial swelling throughout the foot and limited ability to weightbear [11].
- Plantar ecchymosis in the midfoot is pathognomonic for midfoot injury [11].
- Plantar ecchymosis on the plantar aspect of the midfoot implies trauma to the tarsometatarsal ligaments and an injury to that joint [3].

- The physical examination should include evaluation of the dorsalis pedis pulse and deep peroneal nerve function [6].
- Assessment for foot compartment syndrome is required in severe Lisfranc fracture-dislocation [6].

RADIOGRAPHIC EVALUATION

- Diagnostic imaging begins with AP weight-bearing radiographs as well as oblique and lateral views [6].
- Comparison with a weight-bearing AP radiograph of the uninjured foot is often helpful in subtle cases [6].
- Weight-bearing views should be obtained if possible to assess midfoot stability [4].
- CT may be required to define fracture fragments and articular congruity [4].
- If routine radiographs are not diagnostic in a mild injury, stress radiographs taken with the patient under anesthesia may be helpful [6].
- If true weight-bearing radiographs are not possible and advanced imaging is equivocal, there is a role for stress examination under anesthesia to evaluate midfoot stability [11].
- An avulsion fracture at the base of the second metatarsal, known as the fleck sign, represents Lisfranc ligament avulsion [6].
- The fleck sign is better demonstrated on CT and radiography than MRI because fracture fragments may be obscured by marrow and soft-tissue edema on MRI [8].
- On the AP view, the medial border of the second metatarsal should line up with the medial aspect of the middle cuneiform [11].
- On the AP view, there should be less than 2 mm between the first and second metatarsal bases [11].
- On the oblique view, the medial border of the fourth metatarsal should line up with the medial border of the cuboid [11].
- On the lateral view, the dorsal cortex of the first metatarsal should line up with the medial cuneiform [11].
- The lateral base of M1 should be aligned with the lateral margin of C1 on the AP view [8].
- The medial margin of M2 base should be aligned with the medial margin of C2 on AP and oblique views [8].
- Both the medial and lateral margins of M3 base should be aligned with those of C3 on the oblique view [8].
- The medial margin of M4 base should be aligned with the medial margin of the cuboid on the oblique view [8].
- The lateral margin of M5 base should not project more than 3 mm beyond the lateral border of the cuboid on the oblique view [8].
- Minor malalignment may occur in asymptomatic individuals or related to osteoarthritis, with the exception of the relationship between C2 and M2 [8].
- Weight-bearing radiographs usually show lateral displacement of the lesser metatarsals, often with dorsal displacement [8].
- The first metatarsal may dislocate in the same lateral direction (convergent or ipsilateral dislocation) or in the opposite medial direction (divergent) [8].

ADVANCED IMAGING

- MRI is the most sensitive imaging modality for diagnosing Lisfranc injuries, delineating the presence of both osseous and soft-tissue involvement [8].
- Following injury, the Lisfranc ligament may appear edematous and wavy in contour on MRI [8].
- Frank disruption of the ligament fibers associated with avulsion fractures and osseous malalignment may be seen on MRI [8].
- CT is useful if a Lisfranc injury is suspected and plain radiographs are not diagnostic [6].
- MRI is beneficial in more subtle cases to evaluate the status of the Lisfranc ligament and presence of occult fractures [11].
- If other fractures are thought to be present, a CT scan is obtained to better assess the degree of displacement and articular involvement [11].

CLASSIFICATION AND DIAGNOSTIC CRITERIA

- Myerson's modification of the original classification of Quénu and Küss and Hardcastle et al. incorporates more proximal injuries to the medial column of the foot [2].
- Type B injuries involve one or more articulations remaining intact, with Type B1 being medially displaced and Type B2 being laterally displaced [2].
- Type C injuries are divergent injuries that can be partial (C1) or complete (C2), generally associated with high-energy mechanisms [2].
- A classification system for athletes describes Stage I as pain in the Lisfranc joint with no displacement on weight-bearing radiographs and potentially negative bone scan or MRI findings [6].
- Stage II injury is defined by first to second metatarsal diastases of 1 to 5 mm with no evidence of loss of arch on weight-bearing radiographs [6].
- Stage III injury is defined by first to second metatarsal diastases of more than 5 mm and evidence of loss of arch on weight-bearing radiographs [6].
- The common radiographic appearance of malalignment can be classified as transverse or longitudinal depending on whether the pathology extends horizontally across the MTP joints or vertically into the intercuneiform space [6].
- An injury with more than 2 mm of displacement or instability requires surgical management [12].
- Even minimally displaced (<2 mm) Lisfranc injuries are associated with a high rate of instability, with over half of patients treated nonsurgically developing subsequent displacement [12].

Treatment

NON-OPERATIVE

- Nonoperative treatment of Lisfranc injuries is linked to an increased incidence of secondary displacement [1].

- Nonoperative treatment of Lisfranc injuries is linked to inferior functional outcomes [1].
- Nondisplaced Lisfranc injuries with minimal articular involvement are treated conservatively in a boot [4].

OPERATIVE

- Primary open reduction and internal fixation (ORIF) is the preferred method of treatment when there is structural ligamentous instability or fracture–dislocation [1].
- Surgical reconstruction of Lisfranc injuries reestablishes normal gait biomechanics [1].
- Surgical reconstruction of Lisfranc injuries prevents secondary arthritis [1].
- Surgical reconstruction of Lisfranc injuries improves functional outcome [1].
- The key factors for successful surgical treatment are restoration of anatomical alignment and articular congruity [1].
- Operative intervention is indicated when the Lisfranc ligament function is compromised by avulsion from the base of the second metatarsal [4].
- Primary arthrodesis may be indicated in true tarsometatarsal (TMT) dislocations because long-term stability depends on ligamentous healing, which is less reliable than bony healing [4].
- Screw fixation can be used to hold the second metatarsal reduced and transfix the first tarsometatarsal joint [4].
- Instability of the intercuneiform joint noted during Lisfranc fixation requires additional fixation [4].
- Primary arthrodesis of the first through third tarsometatarsal joints is a treatment option for Lisfranc injuries with dorsolateral dislocation [4].
- Provisional Kirschner-wire fixation can be used for the fourth and fifth tarsometatarsal joints during primary arthrodesis of the medial three joints [4].
- Open reduction and internal fixation is required to stabilize associated plantar fracture-dislocations of the navicular in Lisfranc injuries [4].

PROGNOSIS AND COMPLICATIONS

- Insufficient treatment of Lisfranc injuries can lead to painful secondary deformity [1].
- Insufficient treatment of Lisfranc injuries can lead to impaired function [1].
- The prognosis of an untreated Lisfranc fracture is generally poor [3].
- Patients sustaining tarsometatarsal injuries are often confronted with a prolonged convalescence [1].
- Tarsometatarsal injuries jeopardize full social, athletic, and professional reintegration [1].

References

[1] Rockwood And Green S Fractures In Adults. 67: Fractures and Dislocations of the Midfoot and Forefoot > Tarsometatarsal (Lisfranc) Joint Injuries > Introduction to Tarsometatarsal Joint Injuries.

[2] Campbell S Operative Orthopaedics 4 Volume Set. PERCUTANEOUS REDUCTION AND FIXATION OF CALCANEAL FRACTURE > FRACTURE-DISLOCATIONS OF THE TARSOMETATARSAL ARTICULATION (LISFRANC JOINT).

[3] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Pigmented Villonodular Synovitis and Giant Cell Tumor of the Tendon Sheath > Tarsometatarsal (Lisfranc) Fractures > Clinical Features.

[4] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > MIDFOOT INJURIES (EXCLUDING LISFRANC INJURIES).

[5] Miller S Review Of Orthopaedics. MIDFOOT INJURIES (EXCLUDING LISFRANC INJURIES).

[6] Orthopaedic Knowledge Update Sports Medicine 6. Ankle and Foot Injuries and Other Disorders > Foot Disorders > Lisfranc Fracture-Dislocation.

[8] Orthopaedic Knowledge Update Sports Medicine 6. Imaging of the Foot and Ankle > Lisfranc Ligament.

[9] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > TARSOMETATARSAL FRACTURES AND DISLOCATIONS (LISFRANC INJURY).

[10] Miller S Review Of Orthopaedics. TARSOMETATARSAL FRACTURES AND DISLOCATIONS (LISFRANC INJURY).

[11] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Foot and Ankle Reconstruction > Lisfranc Injuries.

[12] Orthopaedic Knowledge Update Trauma. Foot Fractures and Dislocations > Midfoot Injuries > Tarsometatarsal and Lisfranc Fractures.

[13] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Pigmented Villonodular Synovitis and Giant Cell Tumor of the Tendon Sheath > Tarsometatarsal (Lisfranc) Fractures > Classification.

[19] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Pigmented Villonodular Synovitis and Giant Cell Tumor of the Tendon Sheath > Tarsometatarsal (Lisfranc) Fractures > Mechanism of Injury.