Management of Lisfranc Injuries

A Critical Analysis Review

Thomas H. Carter, MD, FRCSEd(Tr&Orth)

Nicholas Heinz, MMedSci, MRCSEd

Andrew D. Duckworth, MSc, PhD, FRCSEd(Tr&Orth)

Timothy O. White, MD, FRCSEd (Tr&Orth), FFTEd

Anish K. Amin, PhD, FRCSEd(Tr&Orth)

Investigation performed at Edinburgh Orthopaedics, Edinburgh, United Kingdom

Abstract

» There is a spectrum of midtarsal injuries, ranging from mild midfoot sprains to complex Lisfranc fracture-dislocations.

» Use of appropriate imaging can reduce patient morbidity, by reducing the number of missed diagnoses and, conversely, avoiding overtreatment. Weight-bearing radiographs are of great value when investigating the so-called subtle Lisfranc injury.

» Regardless of the operative strategy, anatomical reduction and stable fixation is a prerequisite for a satisfactory outcome in the management of displaced injuries.

» Fixation device removal is less frequently reported after primary arthrodesis compared with open reduction and internal fixation based on 6 published meta-analyses. However, the indications for further surgery are often unclear, and the evidence of the included studies is of typically low quality. Further high-quality prospective randomized trials with robust cost-effectiveness analyses are required in this area.

» We have proposed an investigation and treatment algorithm based on the current literature and clinical experience of our trauma center.

The Lisfranc injury is named after a French gynecologist and field surgeon after he defined an amputation through the tarsometatarsal joints (TMTJs)[1], although the injury itself was described by Napoleon's surgeon Larrey. The term implies disruption of this joint with resulting midfoot instability and encompasses a spectrum of injuries to bone and/or ligamentous structures[2]. Lisfranc injuries are rare making up only 0.2% of all orthopaedic presentations, although recent literature suggests a rising incidence, with unstable injuries now more common in women[3]. Some injuries are frequently missed; these are commonly subtle injuries sustained through low-energy mechanisms or in individuals with distracting injuries, such as the polytraumatized patient. If not identified and treated promptly, these injuries carry high morbidity, typically by accelerated midfoot degeneration and arch collapse[4-6]. This, in turn, may lead to substantial functional impairment and in some cases, loss of employment[7]. Open reduction and internal fixation (ORIF) of these injuries after delayed diagnosis of up to 6 weeks is possible[8], but outcomes are less satisfactory compared with timely intervention.

This article reviews the surgical anatomy, presentation, and diagnosis of Lisfranc injuries, followed by a comprehensive overview of treatment, concentrating on the contemporary literature published over the past decade. A review of subtle Lisfranc injuries in athletes has been published recently[9] and is not this article's focus.

Relevant Surgical Anatomy

The Lisfranc joint and the Lisfranc ligament complex are not to be confused and

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have traditionally been ill-defined[10]. The Lisfranc joint consists of all the TMTJs reinforced by soft-tissue stabilizers, namely the Lisfranc ligament complex, intermetatarsal ligaments (connecting metatarsals II-V, but importantly not I-II), intertarsal ligaments, and TMTJ capsular connections. In the coronal plane, the Lisfranc joint is formed of contributions from the metatarsal bases and their respective cuneiforms, which are narrower on the plantar side, resulting in a Roman arch (Fig. 1). The second metatarsal is recessed between the first and third metatarsals, abutting the middle cuneiform and forming the arch keystone, which if compromised, destabilizes the midfoot complex.

Reduced second metatarsal length, relative to foot length, may be a predisposing factor to a ligamentous Lisfranc injury[11]. A number of anatomical variations of the Lisfranc ligament complex have been described[12-14] but, in summary, consists of plantar, interosseous, and dorsal components, which span between the second metatarsal base and the lateral aspect of the medial cuneiform[10,12] (Fig. 1). Two key plantar ligaments exist: a shorter longitudinal ligament from the medial cuneiform to the lateral aspect of the second metatarsal base and a long oblique ligament, which extends to the third metatarsal base[14,15]. The interosseous ligament is the largest and strongest, often referred to as the "Lisfranc ligament," which if sectioned in isolation in a cadaveric setting, results in diastasis[16]. Variations in the structure of the interosseous and plantar ligaments, specifically, may play a role in susceptibility to injury[10].

Clinical Presentation

Up to 70% of Lisfranc injuries occur after a high-energy mechanism, with over 40% sustained during road traffic accidents[17], although some studies have noted a higher proportion of low-energy injuries and are likely related to the catchment population[3]. Lower energy injuries usually occur by a sudden downward rotational force and are more commonly sustained during sports activities[9,18-20]. Despite a better understanding of the pathoanatomy of these specific injuries[21], they are frequently missed at the time of initial presentation or diagnosed late because they are largely isolated ligamentous in nature without an associated fracture[22]. Late presenting patients with persistent pain should be investigated for a missed Lisfranc injury. They may exhibit a bony prominence over the medial aspect of the midfoot, a so-called Jut sign[23]. Compared with low-energy injuries, high-energy injuries are more commonly associated with lateral ray involvement and tarsal bone fractures, predominantly the cuboid and navicular. Compartment syndrome of the foot must be considered in high-energy injuries[24,25]. Regardless of the mechanism, in the presence of midfoot pain, swelling, and/or plantar ecchymosis, a high index of suspicion is required to avoid missed diagnoses[26].

Investigations

Non–weight-bearing radiographs are the primary investigation of choice. Anteroposterior (AP), 30-degree internal oblique, and lateral radiographs may demonstrate a diastasis between the medial cuneiform and the second metatarsal base and/or a radiographic "fleck sign," which are typically pathognomic[27]. However, these may miss subtle injuries, and if there is ongoing clinical concern, weight-bearing radiographs of both feet to allow side-to-side comparison, when pain allows, are recommended[3,28-31] (Fig. 2). This is a routine practice at the authors' institution 10 to 14 days after injury and may highlight not only instability between the medial and middle columns, but not infrequently unmask instability at the first TMT joint (Fig. 5). Side-to-side asymmetry or a distance of >2 mm between the second metatarsal base and the medial cuneiform is highly specific (96%) in aiding in the diagnosis of a ligamentous injury[32]. Deep learning algorithms have reduced misdiagnosis of subtle injuries by a factor of 10[33].

Dividing the foot into 3 columns (medial, middle and lateral) helps visualize the normal alignment of the anatomical zone of interest (Fig. 3). The

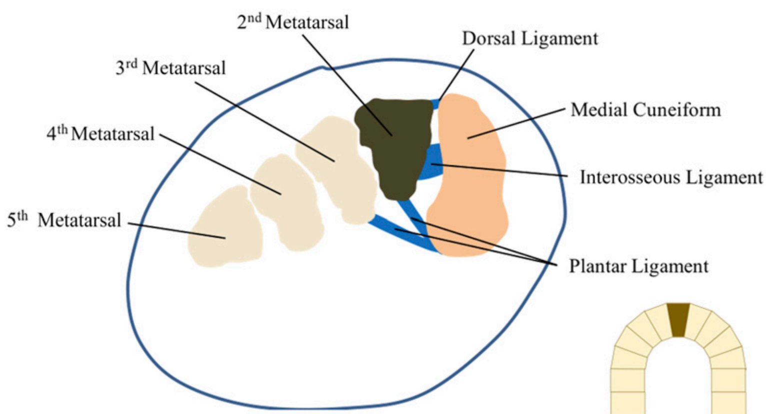

Fig. 1

The Roman arch of the midfoot showing the Lisfranc ligament complex.

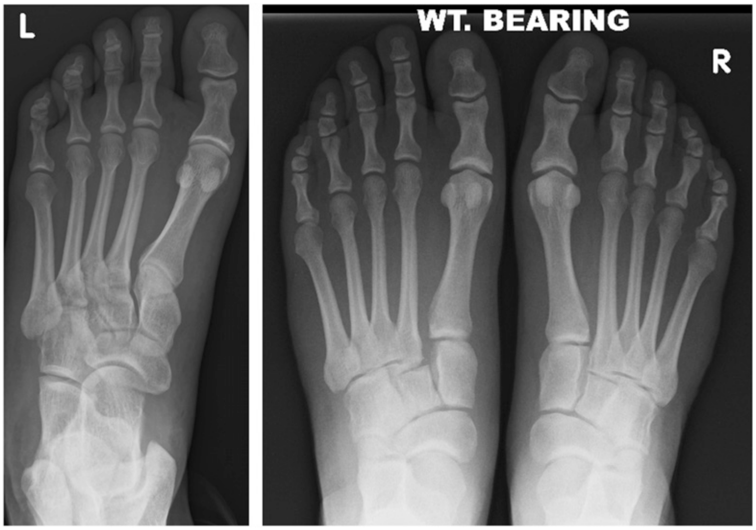

Fig. 2
Non–weight-bearing anteroposterior radiograph of the left foot initially reported as normal. Subsequent bilateral weight-bearing foot radiographs clearly demonstrate a ligamentous Lisfranc injury on the left side.

medial and middle columns are inherently rigid, both acting to stabilize the midfoot during gait. Comparatively, the lateral column permits more movement in all planes, allowing an adaptive foot position when navigating uneven surfaces. TMTJ alignment on weight-bearing radiographs should be scrutinized; the medial border of the second metatarsal should align with the medial border of the middle cuneiform on the AP radiograph, and similarly, the medial border of the fourth metatarsal should align with the medial border of the cuboid on the oblique radiograph. Dorsal displacement on the lateral weight-bearing radiograph is evaluated by the assessment of collinearity between the metatarsal bases and their respective cuneiforms.

At the Lisfranc joint, a fleck sign, when present, may indicate an osseous avulsion from either side of the Lisfranc ligament and a diastasis of >2 mm raises suspicion of underlying injury. Loss of radiographic arch height, visualized on the lateral radiograph, may occur after injury[31,32]. Although not extensively studied in the literature, it may serve as an adjunct in the diagnosis of subtle injuries and/or in confirming accurate reduction intraoperatively. Injury to the first TMTJ, including articular damage, fracture, and/or joint incongruity, may occur in up to 86% of cases and has been overlooked previously[34]. Fractures of the second metatarsal base with no evidence of radiographic instability at the Lisfranc joint are commonly (but incorrectly) interpreted as Lisfranc injuries and are treated conservatively.

If weight-bearing radiographs are not tolerated or if these are normal despite ongoing suspicion, cross-sectional imaging including computed tomography (CT) or magnetic resonance imaging (MRI) may be helpful. CT is valuable in detecting occult

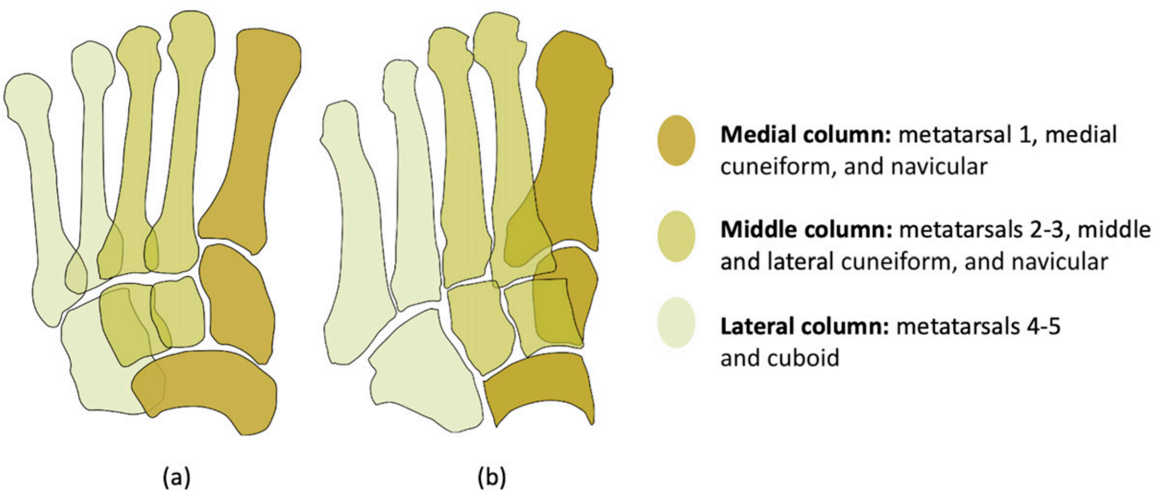

Fig. 3
Anteroposterior (**Fig. 3-A**) and oblique (**Fig. 3-B**) schematics of the tarsometatarsal region of the foot, demonstrating the 3 columns of the foot.

fractures, joint comminution, and minor degrees of joint subluxation that may be missed on radiographs[35], and 3-dimensional reconstructions improve diagnostic accuracy and reliability compared with 2-dimensional interpretation[36]. Recognition of articular injury may aid in surgical decision making when considering primary arthrodesis (PA). CT is further recommended in high-energy injuries where coexisting fractures, if detected, may affect surgical management and/or postoperative rehabilitation (Fig. 4). If previous investigations have been normal and there is continuing concern regarding the injury, MRI is superior in revealing the so-called subtle injury[28,35,37,38]. Stress testing under anesthesia has been performed historically, but with advances in imaging, is now seldom used for diagnostic purposes, although commonly performed at the time of operative stabilization. In summary, the diagnosis of a Lisfranc injury can be very challenging. A high index of suspicion based on the clinical presentation, combined with appropriately selected imaging studies, is essential to reduce the number of missed injuries.

Classification of Injury

Numerous classifications of Lisfranc injury have been proposed[30,39,40]. The most commonly used is the Myerson-modified Hardcastle classification, described in 1986 based on anatomical zone, direction of displacement, and TMTJ congruity[40]. Injuries are classified into 3 main groups (A/B/C), with a fourth group (D) added in 2018[41]. This supplementary group relates to nondisplaced injuries and is further divided into D1 and D2, depending on whether nonoperative intervention is appropriate. Although this classification system has shown excellent intraobserver and interobserver reliability (intraclass correlation coefficient of 0.94 and 0.81, respectively)[42], it is considered less useful in guiding management or predicting prognosis[43]. A classification system for Lisfranc injuries in athletes[9,20] produced by Nunley and Vertullo in a study of 15 athletes used a combination of clinical examination, weight-bearing radiographs, and bone scintigrams[30]. In summary, no classification system exists that definitively helps guide treatment.

Treatment

Nonoperative

Patients presenting with clinical features suggestive of a midfoot sprain (localized midfoot pain, swelling and/or bruising) but with ≤2 mm gap between the medial cuneiform and the second metatarsal base on weight-bearing radiographs and/or CT/MRI imaging may be suitable for nonoperative treatment in appropriately selected patients[40,44]. Ponkilainen et al. followed up 55 patients of an initial cohort of 110 who were treated initially in a non–weight-bearing cast for 4 to 6 weeks, followed by full weight-bearing for a further 4 weeks[45]. At a minimum follow-up of 2 years, patients reported excellent function according to the visual analog scale (VAS)-foot and ankle, and only 1 patient required delayed operative intervention. This study was limited by the large proportion of patients who did not respond to the questionnaire (36%) and the lack of clinical examination and radiographic outcomes.

Stødle et al. prospectively reviewed 26 patients' stable injuries who received a non–weight-bearing cast for 6 weeks and were evaluated at a median time of 55 months after injury[46]. No patient required surgery, and all returned to employment, although 2 reported limitations with recreation. Chen et al. investigated the rate of displacement after nonoperative treatment of minimally displaced Lisfranc injuries[47].

Fig. 4

Computed tomography imaging with 3-dimensional reconstruction in a patient presenting with a high-energy Lisfranc injury, demonstrating associated cuboid and base of fifth metatarsal fractures.

Fourteen of the 26 patients included (54%) displaced, and 12 required surgery. Despite delayed intervention, patient-reported outcome data were comparable with those patients treated successfully without displacement. The authors concluded that nonoperative treatment is feasible, but close radiographic follow-up is mandatory to detect early displacement. While discomfort may persist after a midfoot sprain, there is currently limited evidence to indicate that surgery improves outcomes, and consequently, high-quality data in this area may help guide the best treatment for this select patient group.

Operative

Percutaneous Fixation

To reduce operative morbidity and expedite recovery, percutaneous fixation has been recommended for subtle, low-energy injuries, which have no lateral column instability and can be reduced anatomically through percutaneous techniques[48-53]. Insertion of a standard anterograde or retrograde Lisfranc screw (from the base of the second metatarsal to the medial cuneiform) has been described[52,54] (Fig. 5). Chen et al. described the technique in 16 consecutive patients who were compared with a control group treated with standard ORIF matched for age, sex, mechanism of injury, and classification[52]. At a mean follow-up of 43 months, patient-reported outcomes according to the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot score and the Manchester Oxford Foot Questionnaire were significantly better in the percutaneous group, coupled with a lower nonsignificant rate of radiographic degeneration.

Similar mid-term findings were reported by Vosbikian et al. in 38 consecutive patients sustaining a low-energy injury[49]. Although no patient experienced a serious complication, 22 patients underwent elective hardware removal, which was offered by the institution. Wagner et al. reviewed 22 patients treated with percutaneous fixation and achieved an anatomic or "near-anatomical" reduction in all[53]. Patients were allowed to weight-bear as tolerated 3 weeks postoperatively and reported excellent rates of return to function.

Only 1 systematic review on percutaneous fixation has been performed by Stavrakakis et al., including just 4 studies, which concluded that percutaneous fixation was simple, safe, and with a low operative morbidity[55]. However, as with any periarticular injury, a positive outcome was reliant on anatomical reduction, and some authors consider an open reduction mandatory for all subtle Lisfranc injuries to prevent missing concomitant joint injury, which if left untreated may lead to post-traumatic arthritis[21]. There are currently no Level 1 prospective data on this topic.

Open Reduction and Internal Fixation

In injuries without significant insult to the articular surface, ORIF is considered the gold-standard treatment, combining anatomical reduction with rigid internal fixation (IF) to restore normal gait and functional outcome[56] maintained at long-term follow-up[57]. Traditionally,

Fig. 5

Subtle right Lisfranc injury seen on an anteroposterior non–weight-bearing radiograph (**Fig. 5-A**), which demonstrated additional instability on stress weight-bearing radiographic assessment between the medial and middle columns and the first tarsometatarsal joint (**Fig. 5-B**). One-year radiographic follow-up after percutaneous reduction and fixation (**Fig. 5-C**).

exposure has been achieved through multiple dorsal longitudinal incisions, separated by a small skin bridge[58]. A single longitudinal, extensile incision centered over the second metatarsal has a comparable soft-tissue complication profile, yet provides superior exposure of the whole Lisfranc joint using up to 3 windows[59]. A transverse incision used for access during arthrodesis procedures in the setting of TMTJ arthrosis has been described[60], but it is used less frequently than longitudinal incisions in the trauma setting.

Debate continues regarding fixation modalities, chiefly transarticular screw fixation and dorsal bridge plating. Most clinical studies are single-center and retrospectively designed and include relatively small patient numbers[61]. Transarticular screws are cheaper and may be less irritating to local soft tissues. Opponents of screw fixation report direct chondral injury and retained intra-articular hardware in the event of screw breakage as primary objections. Bridge plating adds no additional articular insult beyond that imparted by the injury and may provide superior fixation in comminuted fractures, but typically requires greater surgical exposure and the associated risks. Often, removal of dorsal plates has been recommended, although recent data have suggested that retention is safe with comparable outcomes to removal[61]. Although hardware is not routinely removed in our institution, a recent UK study found that 38% of surgeons routinely remove hardware in the anticipation that this optimizes physiological function and reduces the risk of implant breakage[62], although without evidence to support this contention.

In the laboratory, comparable fixation stability has been demonstrated by transarticular screws and dorsal plates when tested in 13 paired cadaveric limbs through cyclic loading[63]. Lau et al. studied a group of 62 patients who underwent transarticular screw fixation, dorsal bridge plating, or a combination[64]. Reduction quality was more predictive of radiographic outcome than fixation choice. However, combination fixation with both screws and plates resulted in worse radiological outcomes, but was often performed in more severe injuries and, therefore, may be a confounding factor. Kirzner et al. reported similar findings in their retrospective review of 108 patients treated with transarticular screw fixation (n = 38), dorsal bridge plating (n = 45), and combination fixation (n = 25)[65]. Those managed with combination fixation reported a poorer mean AOFAS of 63, compared with 71 in the transarticular screw fixation group and 82 in the dorsal bridge plating group. Similar patterns were reported in the secondary outcome measures, including patient satisfaction. Dorsal bridge plating was associated with improved anatomical reduction, but did not reach statistical significance, and there was no difference in complication rates. Again, more severe injuries were managed with combination fixation, commonly including stabilization of all 3 columns of the foot, which could explain the inferior outcomes.

Engelmann et al. conducted a systematic review comparing functional outcomes and complication rates of transarticular screw fixation and dorsal bridge plating[66]. One prospective and 3 retrospective studies were included and found that functional outcome according to the AOFAS was statistically significantly higher in the bridge plating group (mean difference 7 points), although below the minimum clinically important difference (MCID). There was no difference between the 2 groups for rates of infection, hardware removal, chronic pain, or arthrodesis secondary to ongoing pain and/or functional limitation. However, there was a higher incidence of post-traumatic osteoarthritis in the transarticular screw group, potentially linked to the greater degree of chondral injury. Philpott et al. performed a large systematic review and meta-analysis including all fixation strategies, both rigid and flexible[67]. Part of the analysis compared transarticular screw fixation with spanning dorsal plate fixation across individual TMTJs and concluded that plating was nonsuperior in the AOFAS with a mean difference of 5 points, which was neither clinically nor statistically significant. Although lateral column stabilization is infrequently reported, these rays are mobile by design, and therefore, if instability is present after fixation of medial and middle columns, temporary stabilization with Kirschner wires for no more than 6 weeks is typically sufficient to maintain reduction while minimizing stiffness[59].

More high-quality data comparing screw and plate fixation are required, but given the scarcity of Lisfranc injuries and the broad range of injury patterns, conducting meaningful randomized controlled trials (RCTs) on this topic is challenging. Nevertheless, it is clear from the evidence available that anatomical reduction, regardless of fixation strategy, is critical to treatment outcome.

Flexible Fixation Devices

Recreation of the Lisfranc ligament with a flexible fixation device has been investigated in numerous recent biomechanical and clinical studies. Several commercial constructs are available aiming to permit residual movement at the Lisfranc joint, to reduce the incidence of hardware removal, and to minimize implant breakage. Given the flexible nature, any observed advantage will benefit ligamentous injuries only and stabilization of the first TMTJ is not feasible with current devices.

Data from biomechanical studies whereby flexible devices have been tested to failure through cyclical loading have found these devices to be noninferior to rigid fixation[68-70]. Cho et al. compared 31 patients treated with a suture button device with 32 patients treated with a rigid Lisfranc screw[71]. All procedures were performed percutaneously, and hardware was removed within 6 months postoperatively in the rigid screw group only. The suture button was superior according to the AOFAS midfoot score and VAS before screw removal, but no difference was found at

1 year and beyond after hardware removal. Two patients in the suture button group experienced recurrent diastasis with the button failing at the medial cuneiform, compared with 1 diastasis in the screw group.

Cottom et al. evaluated radiographic reduction and functional outcomes after suture button stabilization of the Lisfranc joint supplemented with an intercuneiform screw (medial to middle) in 104 patients with ligamentous injuries[72]. There were 84 patients with a minimum follow-up of 3 years. Mean return to full weight-bearing in a supportive orthosis was 11 days, and no suture buttons failed, required removal, or resulted in significant radiographic degeneration. Patient-reported outcome according to the AOFAS improved from 31 at the time of injury to 90 postoperatively. Supportive data from small retrospective series including both acute[73,74] and chronic injuries[75] have been reported. Concerns regarding fixation purchase in poor-quality bone limit the indication of these implants to younger patients with purely ligamentous injuries, and there are currently no level 1 data to support use. Research including robust cost-effectiveness analyses to justify the increased implant cost balanced against the potential reduction in hardware removal rates is needed. A protocol for a meta-analysis of comparative studies has been published[76].

Internal Fixation vs. Primary Arthrodesis

Historically, arthrodesis was reserved as a salvage option for either late presenting patients or after failed initial treatment[77]. However, there is some evidence that PA may provide superior results to IF in select patient groups, including injuries that are purely ligamentous, high-energy, and/or in the presence of severe articular damage at the time of injury. There are currently 6 published meta-analyses on this topic[78-83] (Table I). However, the heterogenous nature of the described surgical techniques and injuries included, make it challenging to draw firm conclusions.

Stødle et al. randomized 48 patients with unstable Lisfranc injuries to IF (n = 24) or PA (n = 24) and completed follow-up to 2 years[84]. In the PA group, the medial 3 TMTJs were fused primarily, whereas in the IF group, a temporary bridge plate was placed over the first TMTJ, with the second and third TMTJs fused as per the PA group. The mean AOFAS and median VAS pain scores were comparable between the 2 groups at both the 1 and 2-year assessment points. In those patients treated with IF, 46% (n = 11) developed post-traumatic degenerative changes in the first TMTJ, but only 1 patient required secondary arthrodesis. So et al. performed a retrospective study comparing complications and reoperation rates in 130 patients treated with IF and 66 patients treated with PA[85]. The reoperation rate was significantly higher in the fixation group (78% vs. 20%), but when hardware removal cases were excluded, the reoperation rates were comparable, as were the overall complication rates. van den Boom et al. performed a recent comprehensive systematic review on the topic[79]. Twenty studies (12 suitable for meta-analysis) were included, with 392 patients treated with IF and 249 patients with PA. The RCT performed by Stødle et al.[84] was part of this review and according to the Grading of Recommendations Assessment, Development and Evaluation criteria, was the only study to yield high-level evidence in relation to the primary outcome (AOFAS midfoot score). Overall, PA performed

TABLE I Summary of Results from Current Meta-analyses in the Literature*

Meta-analysis	Year	No. of Studies and Patients Included	Key Conclusions
van den Boom et al.[79]	2021	20 including 3× RCTs	PA statistically better according to the AOFAS score, but below MCID
		435 patients: 252 ORIF, 183 PA	Hardware removal higher after ORIF
Alcelik et al.[82]	2020	8 including 2× RCTs	No difference in any functional outcome
		547 patients: 389 ORIF, 158 PA	Hardware removal higher after ORIF
Yammine et al.[80]	2019	6 including 1× RCT	Return to duty favored PA
		269 patients: 176 ORIF, 93 PA	Hardware removal higher after ORIF
Magill et al.[78]	2019	5 including 2× RCTs	No difference in functional outcomes
		187 patients: 117 ORIF, 70 PA	Hardware removal higher after ORIF
Han et al.[83]	2019	7 including 2× RCTs	PA statistically better according to the AOFAS score, but below MCID
		287 patients: 184 ORIF, 103 PA	Return to duty and pain VAS favored PA
			Hardware removal higher after ORIF
Smith et al.[81]	2016	3 including 2× RCTs	No difference in revision surgery or functional outcomes
		95 patients: 50 ORIF, 45 PA	Hardware removal higher after ORIF

*AOFAS = American Orthopaedic Foot and Ankle Score, MCID = minimum clinically important difference, ORIF = open reduction and internal fixation, PA = primary arthrodesis, RCT = randomized controlled trial, and VAS = visual analog scale.

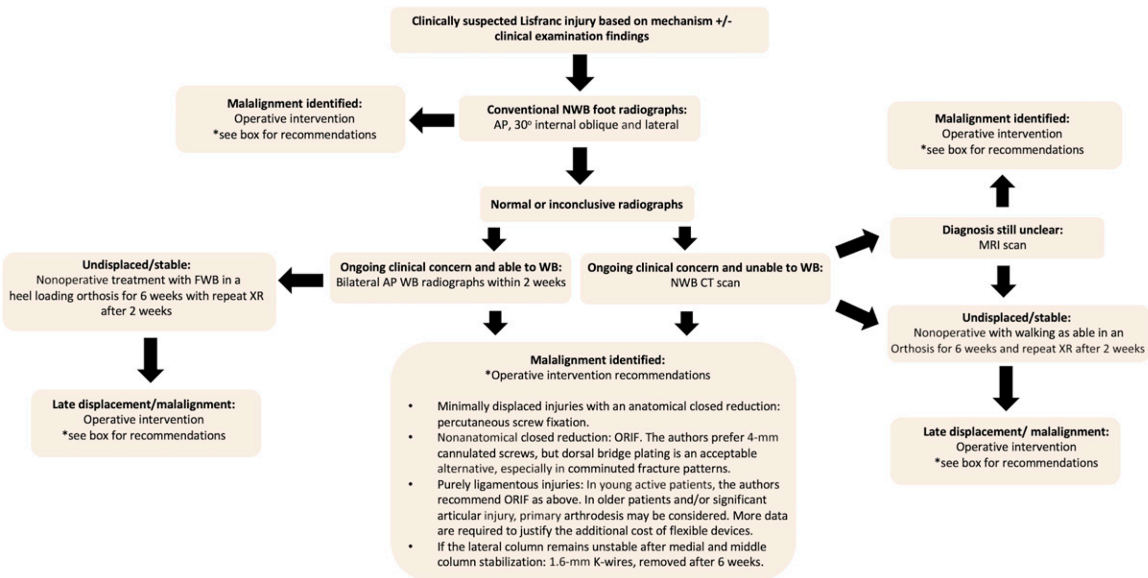

Fig. 6

Algorithm for diagnosis and management of Lisfranc injuries based on the current literature and clinical experience of our trauma center. AP = anteroposterior, CT = computed tomography, FWB = full weight-bearing, MRI = magnetic resonance imaging, NWB = non–weight-bearing, ORIF = open reduction and internal fixation, and WB = weight-bearing.

statistically significantly better than IF (AOFAS mean difference of 6.3 points), but this value was not felt to be clinically significant and fell below the MCID of 8.4[86]. Furthermore, in addition to the overall quality of evidence being low, it was not possible to differentiate between injury types, energy at the time of injury, and specific fixation strategies. The authors stated explicitly that further large prospective multicenter RCTs, including cost-effectiveness analyses, are required.

Each of the published 6 meta-analyses found that hardware removal rates were lower after PA, but there were conflicting results regarding return to function and functional outcomes. It has since been noted that the studies contained within the meta-analyses used different variations of the AOFAS questionnaire, making direct comparisons invalid[87]. It must also be noted that the published MCID for the AOFAS is based on patients undergoing hallux valgus surgery, and an updated value, specifically for Lisfranc injuries, would be of assistance when drawing future conclusions.

Treatment Outcomes

Early failure may be attributed to multiple factors, including under-appreciation of injury severity, nonanatomical reduction, incorrect implant selection, and nonunion. Surgical arthrodesis in these situations provides the most reliable salvage option[77,88]. After successful initial treatment, there are limited studies reporting the longer term outcome of Lisfranc injuries, with the few available reporting outcomes from small cohorts[57,89,90]. Dubois-Ferrière et al. followed up 61 patients at 11 years and reported satisfactory patient-reported outcome (AOFAS mean score 79) but with evidence of radiographic degeneration in 72% of patients[90]. Half of the cohort had symptomatic degeneration, which was associated with poorer outcomes, but only 4 patients required reintervention. Others have also found no association between radiographic osteoarthritis and poor clinical scores, although this cohort was treated with Kirschner wire stabilization[89], which may not provide as predictable fixation as screws or plates. However, these studies highlight the fact that the development of radiographic osteoarthritis does not in itself necessitate secondary arthrodesis and patients should be assessed for symptom correlation and not through radiographs alone. Given the young age of many patients in this cohort, return to activity, including sport after treatment, has been addressed in recent literature[9,20,91-95]. Rates of return to sport of 94%, with nearly three-quarters returning to preinjury levels, have been reported in a recent meta-analysis[92]. By contrast, change of employment or indeed unemployment after injury may occur in up to 30% of patients[7], particularly after delayed diagnosis or in the presence of a workers' compensation claim.

Management Algorithm for Lisfranc Injuries

Based on the current literature and the experience of the authors' institution, we have proposed an investigation and treatment algorithm for managing Lisfranc injuries (Fig. 6).

Conclusions

Lisfranc injuries are varied and often complex, presenting numerous management challenges (Table II). Weight-bearing imaging should improve diagnostic accuracy and reduce the number of missed or late diagnoses. Nonoperative treatment is successful in undisplaced injuries but requires careful

TABLE II Grades of Recommendation for the Investigation and Management of Lisfranc Injuries

Recommendations for Care	Grade*
Anatomical variability of the Lisfranc joint and associated ligamentous complex play a role in the susceptibility to injury and variation of injury patterns.	C
Weight-bearing radiographs improve the diagnostic accuracy when investigating the "subtle" low-energy Lisfranc injury.	B
Percutaneous reduction and fixation of minimally displaced Lisfranc injuries results in satisfactory clinical and radiographic outcomes.	B
Once anatomical reduction has been achieved, transarticular screws and dorsal bridge plating can both be considered to stabilize the Lisfranc joint complex.	B
Primary arthrodesis should be considered in elderly patients and/or injuries with a significant insult to the articular surface.	B
Flexible fixation devices are not superior to rigid fixation according to the current evidence. High-quality Level I data are awaited to make further recommendations.	C

*Grade A: Good evidence (Level I studies with consistent findings) for or against recommending intervention. Grade B: Fair evidence (Level II or III studies with consistent findings) for or against recommending intervention. Grade C: Conflicting or poor-quality evidence (Level IV or V studies) not allowing a recommendation for or against intervention. Grade I: There is insufficient evidence to make a recommendation.

radiographic surveillance to detect late displacement. In the presence of an anatomical closed reduction, percutaneous stabilization is safe with low complication rates. Because reduction quality is a marker of treatment outcome, a low threshold for performing an open reduction should be always used. Once reduced, the choice of implant for stabilization may be left to surgeon discretion. While some studies claim to support PA over IF, most have been unable to detect a clinically meaningful difference in functional outcomes and concerns persist regarding primary TMTJ fusion in young active patients. Flexible fixation devices may reduce hardware removal rates but are limited in their application to purely ligamentous injuries only. Further high-quality studies comparing these treatment options including cost-effectiveness analyses are required.

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Thomas H. Carter, MD, FRCSEd(Tr&Orth)[1],
Nicholas Heinz, MMedSci, MRCSEd[1],
Andrew D. Duckworth, MSc, PhD, FRCSEd(Tr&Orth)[1,2],
Timothy O. White, MD, FRCSEd (Tr&Orth), FFTEd[1],
Anish K. Amin, PhD, FRCSEd(Tr&Orth)[1]

[1]Edinburgh Orthopaedics, Royal Infirmary of Edinburgh, Edinburgh, United Kingdom

[2]Centre for Population Health Sciences, Usher Institute, University of Edinburgh, Edinburgh, United Kingdom

Email address for corresponding author: andrew.duckworth@ed.ac.uk

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