Foot and Ankle Surgery 25 (2019) 654–664

Contents lists available at ScienceDirect

Foot and Ankle Surgery

journal homepage: www.elsevier.com/locate/fas

Return to sport following Lisfranc injuries: A systematic review and meta-analysis

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ARTICLE INFO

Article history:
Received 25 April 2018
Received in revised form 17 July 2018
Accepted 24 July 2018

Keywords:
Lisfranc
Tarso-metarsal
Mid-foot
Return
Sport
Rate
Time

ABSTRACT

Background: Information regarding return rates (RR) and mean return times (RT) to sport following Lisfranc injuries remains limited.
Methods: A systematic search of nine major databases was performed to identify all studies which recorded RR or RT to sport following lisfranc injuries.
Results: Seventeen studies were included (n = 366).
For undisplaced (Stage 1) injuries managed nonoperatively (n = 35), RR was 100% and RT was 4.0 (0–15) wks. For stable minimally-displaced (Stage 2) injuries managed nonoperatively (n = 16), RR was 100% and RT was 9.1 (4–14) wks.
For the operatively-managed injuries, Percutaneous Reduction Internal Fixation (PRIF) (n = 42), showed significantly better RR and RT compared to both: Open Reduction Internal Fixation (ORIF) (n = 139) (RR — 98% vs 78%, p < 0.019; RT — 11.6 wks vs 19.6 wks, p < 0.001); and Primary Partial Arthrodesis (PPA) (n = 85) (RR — 98% vs 85%, p < 0.047; RT — 11.6 wks vs 22.0 wks, p < 0.002).
Conclusions: Stage 1 and stable Stage 2 Lisfranc injuries show good results with nonoperative management. PRIF offers the best RR and RT from the operative methods, though this may not be possible with high-energy injuries.
Level of Evidence: IV. Systematic Review of Level I to Level IV Studies.

1. Introduction

Lisfranc Injuries comprise a group of injuries to the tarso-metatarsal joint complex, which range from sprains of the ligamentous structures to fracture-dislocations [1–7]. While relatively rare, occurring at an incidence of 1 per 55,000 population and comprising only 0.2% of all fracture injuries [8,9], their incidence within certain sporting population is high, with study data recording up to 4% of collegiate American football players suffer from this injury [10].

Lisfranc injuries can be categorised by the severity of injury mechanism: high-energy injuries result in severe disruption of the tarso-metatarsal joint complex, and are most commonly seen following high-impact road traffic accidents and falls from significant height; low-energy injuries most often result in partial disruption and sprains to the tarso-metatarsal joint complex, and more commonly occur with sport-related injuries [7,11–13].

These injuries can be divided into those which comprise ligamentous injury alone, and those which comprise both ligamentous and fracture injuries [13–16].

The ligamentous injuries are commonly classified using the Nunley classification which is: Stage 1— Lisfranc diastasis <2 mm on antero-posterior (AP) weightbearing radiographs; Stage 2 — Lisfranc diastasis 2–5 mm with no loss of mid-foot arch on lateral radiographs; Stage 3 — Lisfranc diastasis >5 mm with loss of midfoot arch or height on lateral radiographs [17]. Stage 2 injuries can be further sub-divided into those which are stable, with no increase in diastasis or deformity on stress testing, examination under anaesthetic (EUA) or serial follow-up; and those which are unstable, with increase in diastasis or deformity following stress testing, EUA or serial follow-up [18]. Avulsion fractures are commonly grouped under ligamentous injuries given the similar injury pattern [19].

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https://doi.org/10.1016/j.fas.2018.07.008
1268-7731/

The osseous–ligamentous (fracture) injuries are commonly classified using the Myerson classification, namely Type A — total incongruity with either medial or lateral displacement of the metatarsal complex; Type B — partial incongruity with medial displacement of the first ray; Type B2 — partial incongruity with lateral displacement of the lesser rays; Type C1 — divergence with partial incongruity; and Type C2 — divergence with total incongruity [20].

The management of these injuries is based on the nature of the injury, the degree of displacement and patient factors [3,21,22].

Usually, undisplaced injuries are treated non-operatively with immobilisation in a cast or orthotic boot, restricted weight bearing, followed by a period of rehabilitation with medial arch supports [1,3–5,15].

Displaced fracture and ligament (diastasis >5 mm) injuries are routinely treated by either Percutaneous Reduction Internal Fixation (PRIF), Open Reduction Internal Fixation (ORIF), or Primary Partial Arthrodesis (PPA) [1,3–5,15].

There remains debate regarding the management of minimally displaced ligament injuries (diastasis 2–5 mm): some advocate operative reduction and fixation in all cases [4,6,15,16]; while others advocate non-operative management for stable injuries, and operative management for unstable injuries [18].

Despite established treatment principles, the outcome data for such injuries, regarding return to sport, is limited [1,5,6,12]. Thus, it remains unclear which mode of management provides the optimal outcome for athletes following these injuries [1,5,6,12].

This systematic review assesses all studies in the literature which report on return rates and return times to sport following Lisfranc injuries to determine the optimal management methods for such injuries in athletic patients.

2. Methods

2.1. Literature search

A systematic literature search was performed in April 2018 using the following databases: Medline (PubMED), EMBASE, CINAHAL, Cochrane Collaboration Database, Google Scholar, SPORTDiscus, Physiotherapy Evidence Database (PEDro), Scopus, and Web of Science. This was performed to locate all articles, in the English language, in peer-reviewed journals, reporting on return rates and return times to sports following Lisfranc Injuries. No distinction was made regarding the nature of the injury, nor the level or type of sport performed. The keywords used for the search were 'Lisfranc'; 'tarso-metatarsal'; 'mid-foot'; 'injury'; 'ligament'; 'fracture'; 'sprain'; 'athletes'; 'sports'; 'non-operative'; 'conservative'; 'operative'; 'return to sport'. There was no restriction in relation to the year of publication.

The authors adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) guidelines when performing the review [23]. Three of the authors (1) Gregory Aidan James Robertson. 2) Kok Kiong Ang. 3) Alexander MacDonald Wood) performed the article review process. All three independently reviewed the abstracts of each publication to establish its suitability for inclusion within the study. In accordance with the PRISMA guidelines, the inclusion and exclusion criteria for the review are presented in Table 1 [23]. Fig. 1 demonstrates the quality of reporting of meta-analyses (QUORUM) flow diagram [23]. Article categories deemed unsuitable for inclusion in the review included biomechanical reports, case reports, expert opinions, instructional courses, literature reviews, and technical notes, unless relevant patient data was contained within these. When exclusion could not be performed from the abstract directly, the full version of the article was downloaded to decide their suitability to be included in the present investigation. A systematic search through the reference lists of the included articles and relevant review articles was also performed to locate additional articles suitable for inclusion. Discrepancies in the choice of articles for inclusion were resolved by consensus discussion between the three reviewers.

The study database contained information on patient demographics, mechanism of injury, pre-operative imaging investigations, injury nature and severity, operative and non-operative management techniques, return rates to sport, return times to sports, return rates to pre-injury level of sport, complications, and predictive factors for return to sports. Return rates to sport and return times to sport were the primary outcome measures for the review. Return rates to pre-injury level of sport and associated complications were the secondary outcome measures. For non-operative management, return time to sport was defined as the time from the commencement of conservative treatment to return to sport; for operative management, return time to sport was defined as the time from the commencement of primary operative treatment to return to sport. Where conversion to a secondary treatment was required, with return to sport not possible from the primary treatment method, this was recorded as a non-return to sport for the primary treatment method; required secondary treatment methods are listed in the complications section in Table 2.

2.2. Quality assessment

The modified Coleman Methodology Score (CMS) was used to grade the quality of the included studies [24]. This scoring system has been previously used within multiple similar systematic reviews, reporting on return to sport following various injuries [25–33]. The scoring of the included articles was performed by two of the authors (1) Gregory Aidan James Robertson. 2) Kok Kiong Ang. 3) Alexander MacDonald Wood). Assessment of the inter-observer reliability of the scores, through the intra-class correlation co-efficient statistic, was 0.94 (95% confidence interval (CI) 0.92–0.96).

2.3. Statistics

RevMan Version 5.3 (The Cochrane Group) was used to perform the meta-analysis comparisons. Comparisons were performed on return rates to sport, return times to sport and return rates to pre-

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Acute lisfranc injuries	Chronic lisfranc injuries
Elite or recreational athletes	Tarso-metatarsal injury without Lisfranc involvement
Return rate to sporting activity reported	No sporting outcome data reported
Time to return to sporting activity reported	Paediatric fractures (age under 15)
Two or more injuries reported	Concomitant upper or lower limb fractures
Peer-reviewed journals	Reviews, case reports, abstracts or anecdotal articles
English language	Animal, cadaver or in vitro studies

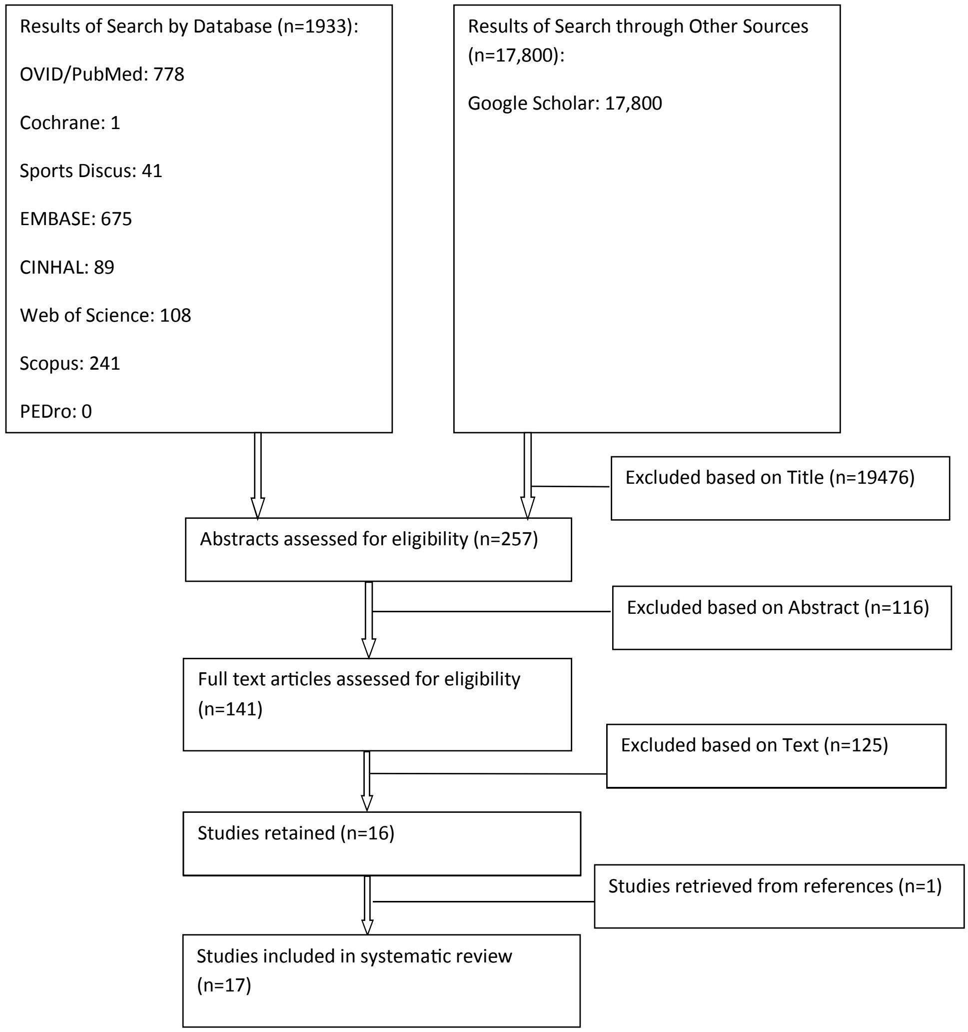

Fig. 1. Selection of articles for inclusion in the review in accordance with the PRISMA protocol [23].

injury level of sport between synthesis cohorts of sufficient size. For dichotomous data, odds ratios (ORs) were reported for comparison assessment, using a random effects model. For continuous data, mean differences (MDs) were reported for comparison assessment, using a random effects model. Cohort heterogeneity was analysed using the I^2 statistic; this was deemed to be significant with I^2 >50%. The significance level was set at $p < 0.05$.

3. Results

3.1. Search

The details of the review process for the included articles are provided in Fig. 1. In total, 257 abstracts and 141 articles were reviewed.

3.2. Patient demographics

Seventeen relevant publications [10,17–19,34–46] were identified, published from 1993 [39] to 2018 [44], focusing on clinical and functional outcomes of patients who returned to sporting activities following Lisfranc injuries (Table 2). One was a randomised controlled trial (RCT) [41], 12 were retrospective cohort studies [10,17–19,34,35,39,40,42–46], and three were case series [36–38].

Of the 380 Lisfranc injuries, 258 (68%) occurred in male patients, 110 (29%) in female patients, and 12 (3%) failed to specify gender. One patient sustained a bilateral Lisfranc injury [10]. Of the 380 Lisfranc injuries recorded, follow-up data were available for 366 (96.3%). The mean age at the time of injury ranged from 19.3 years [37] to 39.0 years [34], and the sports activity commonly practised were American football, soccer, basketball, running, and gymnastics (Table 2).

3.3. Injury nature and classification

Six studies reported on Lisfranc ligament injuries exclusively [10,17,18,41,45,46]. One study reported on Lisfranc fracture injuries exclusively [35]. Five studies included both Lisfranc ligament and fracture injuries [19,34,38–40]. Five studies reported on Lisfranc injuries in general, failing to differentiate between ligament or fracture injuries (Table 2) [36,37,42–44].

Five of the studies used formal classifications to describe the injuries. One used the Myerson classification system [35], one used both the Myerson and the American Medical Association's Standardized Nomenclature of Athletic Injuries classifications [39], one used both the Nunley and the Myerson classification [40] and two used the Nunley classification [17,18]. Two studies reported on the degree of diastasis present at the Lisfranc joint, but failed to use a specific classification [10,45].

Table 2
Lisfranc Injuries — only injuries with follow-up data included. Mean values unless otherwise stated 1.

Author (year)	N	Injury nature	Study design	Mean follow-up	Treatment	Mechanism of injury	Coleman score	Return rate	Return rate by treatment modality	Return rate to same level of sport	Return time (range)	Return time (range) by treatment modality	Return rate by injury nature	Return time by injury nature	Outcome score	Complications by treatment modality
Abbasian et al. [34]	58	Ligament (29) fracture (29)	RCS	8.7 years	ORIF (58)	Motorvehicle accident (23), falls (18), crush injury (17)	70	46/58	ORIF: 46/58	ORIF: 46/58	n/a	n/a	Ligament 22/29 fracture 24/29	n/a	AOFAS: Ligament — 84 (27–100); fracture — 85 (45-100).	ORIF: ROM (58) malunion (7) conversion to arthrodesis (2)
Bleazy et al. [35]	13	Fracture type B2 (13)	RCS	36 months	PRIF (13)	American football (7), baseball (2), boxing (1), motocross (1), snowboarding (1), volleyball (1)	66	13/13	PRIF: 13/13	PRIF: 13/13	16.6 weeks	PRIF: 16.6 wks	Fractures (B2): 13/13	Fractures (B2): 16.6 weeks	n/a	PRIF: ROM (13)
Brin et al. [36]	5	Lisfranc injury (5)	CS	12 months	Tightrope repair (5)	Motorcycle (2), fall (2), windsurfing (1)	53	5/5	Tightrope: 5/5	Tightrope: 5/5	By 6 months	Tightrope: By 6 months	Lisfranc injury: 5/5	Lisfranc injury: By 6 months	AOFAS: n/a	Tightrope: Nil
Chilvers et al. [37]	3	Lisfranc Injury (3)	CS	n/a	ORIF (2) PRIF (1)	Gymnastics (3)	22	1/3	ORIF: 1/2 PRIF: 0/1	ORIF: 1/2 PRIF: 0/1	n/a	n/a	Lisfranc injury: 1/3	n/a	n/a	ORIF: nil PRIF: revision ORIF (1)
Cottom et al. [38]	2	Fracture type B (1), avulsion fracture (1)	CS	10 months	Interosseous Suture Button (2)	Basketball (1) gym (1)	58	2/2	ISB: 2/2	ISB: 2/2	8 (8–8) weeks	ISB: 8 (8–8) weeks	Fracture (B): 1/1; avulsion fracture: 1/1.	Fracture (B): 8 weeks avulsion fracture: 8 weeks	n/a	ISB: Nil
Curtis et al. [39]	19	Ligament S 1&2 (9), S 3 (3), avulsion fracture (4), fracture Type B2 (3)	RCS	25 months	Non-operative (S1-3 & avulsion fractures) (14), ORIF (S3 & type B2 fractures) (5)	Basketball (6), running (5), windsurfing (4), soccer (2), cricket (1), gymnastics (1).	62	16/19	Non-Op: 11/14 ORIF: 5/5	Non-Op: 9/14 ORIF: 5/5	4.1 (1.5–9) months	Non-Op: 3.5 (1.5-7) months ORIF: 5.4 (4-9) months	Ligament S1&2: 7/9 S3: 2/3 avulsion fracture: 4/4 Fracture (B2): 3/3	Ligament S1&2: 2.9 months S3: 4.5 months avulsion fracture: 4.6 months Fracture (B2): 6 months	Main & Jowett: excellent(10) good (4) fair (4) poor (1)	Non-op: S3 sprain – delayed arthrodesis (1) ORIF: ROM (2)
Deol et al. [40]	17	Ligament S 2 (7) fractures type B (6) type C (4)	RCS	33.8 months	ORIF (15) Primary Partial Arthrodesis (2)	Soccer (11), rugby (6)	65	16/17	ORIF: 14/15 PPA: 2/2	ORIF: 14/15 PPA: 2/2	20.1 (18–24) wks	ORIF: 19.8 (18–23) wks PPA: 22 (20-24) wks	Ligaments S2: 6/7 fractures (B): 6/6 (C): 4/4	Ligaments S2: 19.0 wks fractures (B): 21.0 wks (C): 20.5 wks	n/a	ORIF: ROM (15) Transient paraesthesia (2) Persistent paraesthesia (1) PPA: ROM (2)
Ly et al. [41]	41	Ligament (41)	RCT	42.5 months	ORIF (20) PPA (21)	Motorvehicle accident (22), fall (12), pot-Hole (3), horse-riding (2), basketball (1), ice-Hockey (1)	85	21/41	ORIF: 6/20 PPA: 15/21	ORIF: 6/20 PPA: 15/21	n/a	n/a	Ligament: 21/41	n/a	AOFAS (2y): ORIF – 69 (16-100); PPA – 88 (63-100).	ORIF: ROM (16) Malunion (15) Conversion to arthrodesis (5) PPA: ROM (2) Delayed union (1) Revision

Table 2 (*Continued*)

Author (year)	N	Injury nature	Study design	Mean follow-up	Treatment	Mechanism of injury	Coleman score	Return rate	Return rate by treatment modality	Return rate to same level of sport	Return time (range)	Return time (range) by treatment modality	Return rate by injury nature	Return time by injury nature	Outcome score	Complications by treatment modality
																arthrodesis for non-union (1) Compartment syndrome (1)
MacMahon et al. [42]	37	Lisfranc injury (37)	RCS	5.2 years	Primary Partial Arthrodesis (37)	Twist (15), fall (13), motorvehicle accident (8), crush Injury (1)	63	37/37	PPA: 37/37	PPA: 24/37	n/a	n/a	Lisfranc Injury: 37/37	n/a	FAOS: Sports – 86 (20–100).	PPA: ROM (5)
McHale et al. [43]	28	Lisfranc Injury (28)	RCS	5.6 years	Operative (22), non-operative (6)	American football (28)	46	26/28	Op: 20/22 Non-Op: 6/6	Op: 20/22 Non-Op: 6/6	median 11.1 (interquartile range, 10.3–12.5) months	Operative: median 11.6 (10.7–12.6) months Non-Operative: median 6.2 (1.9–10.7) months	Lisfranc Injury: 26/28	Lisfranc Injury: median 11.1 (interquartile range, 10.3-12.5) months	Offensive and Defensive Power Ratings	Op: nil Non-Op: nil
Meyer et al. [10]	24	Ligament S 1 (21) S 2 (3)	RCS	30.8 months	Non-operative (G1&2) (24)	American football (24)	64	24/24	Non-Op: 24/24	Non-Op: 23/24	13.8 (0–78) days	Non-Op: 13.8 (0–78) days	Ligaments S1: 21/21 S2: 3/3	Ligaments S1: 11.2 (0–58) days S2: 32.3 (1–78) days	Authors' questionnaire	Non-Op: recurrence of injury (4).
Mora et al. [44]	33	Lisfranc injury (33)	RCS	2.9 years	ORIF (33)	n/a	72	31/33	ORIF: 31/33	ORIF: 22/33	n/a	n/a	Lisfranc Injury: 31/33	n/a	FAOS: Sports – 86 (50–100)	ORIF: ROM (33)
Nunley et al. [17]	15	Ligament S 1 (7), S 2 (8)	RCS	27 months	Non-operative (S1) (7) PRIF (S2) (6) ORIF (S2) (2)	American football (10), soccer (2), baseball (1), basketball (1), cross country (1)	64	15/15	Non-Op: 7/7 PRIF: 6/6 ORIF: 2/2	Non-Op: 7/7 PRIF: 6/6 ORIF: 2/2	15.2 (11-20) wks	Non-Op: 15.0 (11-18) wks PRIF: 15.2 (12-20) wks ORIF: 16.0 (16-16) wks	Ligament S1: 7/7 S2: 8/8	Ligament S1: 15.0 wks S2: 15.4 wks	Main & Jowett: excellent(14) good (1)	Non-Op: nil PRIF: nil ORIF: nil
Osbahr et al. [18]	15	Ligament S 1 (7), S 2 (5), S 3 (3)	RCS	5.5 years	Non-operative (S1&2) (12) ORIF (S3) (3)	American football (15)	58	15/15	Non-Op: 12/12 ORIF: 3/3	Non-Op: 11/12 ORIF: 3/3	16.8 days	Non-Op: 11.7 days ORIF: 73 days	Ligaments S1: 7/7 S2: 5/5 S3: 3/3	Ligaments: S1: 3.1 days S2: 26.1 days S3: 73 days	n/a	Non-Op: nil ORIF: ROM (3)
Reinhardt et al. [19]	25	Ligament (12) fractures (13)	RCS	42 months	Primary Partial Arthrodesis (25)	Twist (13), motorvehicle accident (5), fall (4), crush Injury (3)	69	18/25	PPA: 18/25	PPA: 18/25	n/a	n/a	Ligament: 9/12 fracture: 9/13	n/a	AOFAS: PPA – 81 (25-100); Ligament – 83 (49-100); fracture 79 (25-100).	PPA: ROM (4). Revision arthrodesis for non-union (2).
Shapiro et al. [45]	9	Ligament S 2 (9)	RCS	34 months	Non-operative (S2) (8) ORIF (S2) (1)	Gymnastics (4), American football (3), pole Vault (1), tennis (1)	56	9/9	Non-Op: 8/8 ORIF: 1/1	Non-Op: 8/8 ORIF: 1/1	14.7 (6-24) wks	Non-Op: 13.5 (6-20) wks ORIF: 24 wks	Ligament S2: 9/9	Ligament S2: 14.7 wks	n/a	Non-Op: nil ORIF: ROM (1).
	22		RCS				72	22/22								

Table 3
Choice of radiological imaging.

Method of radiological imaging	Number of studies
Radiographs, MRI and CT scans	2 studies [38,40]
Radiographs, MRI, CT scans and fluoroscopic EUA	2 studies [17,44]
Radiographs and CT scans	2 studies [41,46]
Radiographs and isotopic bone scans	2 studies [10,37]
Radiographs and MRI scans	1 study [35]
Radiographs and fluoroscopic EUA as required	1 study [39]
Radiographs alone	1 study [45]
Weightbearing radiographs used	6 studies [17,35,40,44–46]
Imaging modality not specified	6 studies [18,19,34,36,42,43]

Of the 366 Lisfranc injuries with follow-up data, 295 were surgically managed and 71 were conservatively managed. Of the 366 cases, 191 were ligament injuries, 69 were fracture injuries and 106 were generic Lisfranc injuries (Table 2).

3.4. Choice of radiological imaging

The modality of radiological imaging used in each study is listed in Table 3.

3.5. Study design

The mean CMS for all the studies was 61.6 (range 22–85) (Table 2) [10,17–19,34–46]. For the studies reporting on non-operative management, the mean CMS was 58.8 (range 46–64) (Table 2). For the studies reporting on operative management, the mean CMS was 61.5 (range 22–85) (Table 2) [17–19,34–46].

3.6. Management

3.6.1. Non-operative management

There were 71 Lisfranc injuries managed non-operatively [10,17,18,39,43,45]. The management plans varied widely, both within and between studies [10,17,18,39,43,45]. Some patients underwent no formal treatment with immediate return to sport, while others underwent prolonged treatment with immobilisation [10,17,18,39,43,45]. Three studies reported formalised non-operative management plans [17,18,45]. Immobilisation methods included a CAM walker [18]; a removable splint or cast [45]; a well-moulded fibre-glass cast, a weight-bearing ankle-foot orthotic device and custom moulded orthotics [17]. Progression to full weight-bearing ranged 0–6 weeks [10,17,18,39,43,45]. Stage 1 and Stage 2 injuries were treated with the similar protocols [18,45].

3.6.2. Operative management

There were 295 Lisfranc injuries managed operatively [17–19,34–46]. The reported techniques were ORIF (n = 139) [17,18,34,37,39–41,44,45], PPA (n = 85) [19,40–42], PRIF (n = 42) [17,35,37,46] and Tight-Rope/Interosseous Suture Button (n = 7) [36,38].

Indication for operative management varied: some studies advocated surgery for injuries with more than 2 mm diastasis between the bases of the first and second metatarsals, and more than 1 mm of subluxation of the base of one of the metatarsals from its corresponding tarsal bone [46]; other studies reserved operative management for injuries with frank (>5 mm) displacement (Stage 3), treating those with subtle diastasis (2–5 mm) non-operatively, unless they demonstrated signs of gross instability on stress-testing [18].

The postoperative mobilisation regimes varied according to the method of operative fixation used [17–19,34–46].

For studies using ORIF, post-operative immobilisation comprised the use of a cast, splint or moonboot for 4–8 weeks non-weight-bearing, with partial weight bearing by 4–8weeks postoperatively, and full weight-bearing by 8–12 weeks postoperatively [17,18,34,37,39–41,44,45]. Removal of metalwork varied from routine removal of metalwork 8–12 weeks post-surgery [18] to no removal of metalwork unless symptomatic (not less than 3 months post-surgery) [41]; routine removal of metalwork was performed in five studies [18,34,40,44,45].

For studies using PPA, postoperative immobilisation comprised use of a cast, splint or moonboot for 6–8 weeks non weight bearing, with partial weight bearing by 8 weeks postoperatively, and full weight bearing by 8–12 weeks operatively [19,40–42]. Removal of metalwork varied from routine removal of metalwork 16 weeks post-surgery [40] to no removal of metalwork unless symptomatic (not less than 3 months post-surgery) [41]; routine removal of metalwork was performed in one study [40].

For studies using PRIF, postoperative immobilisation comprised use of a cast or splint for 3 weeks non-weight-bearing, weight bearing as able in normal footwear following this [17,35,37,46]. Removal of metalwork varied from routine removal of metalwork 4 months post-surgery [35] to no removal of metalwork unless symptomatic [17,46]; routine removal of metalwork was performed in one study [35].

For studies using TightRope/Interosseous Suture Button, postoperative immobilisation comprised use of a cast for 3–6 weeks non-weight-bearing, with partial weight bearing by 3–6 weeks postoperatively, and full weight-bearing by 6–8 weeks postoperatively [36,38]. No routine removal of the device was performed in either study [36,38].

On commencement of full weight-bearing, all studies advised supervised progression with physiotherapy, with a graduated return to exercise programme [17–19,34–46].

3.7. Functional assessment (Table 2)

Eleven of the studies used validated measures to assess post-intervention functional status [10,17,19,34,36,39,41–44,46]. The reported scores included the American Orthopaedic Foot and Ankle Society Mid-Foot Score (5 studies) [19,34,36,41,46], Visual Analogue Score for pain (3 studies) [19,34,41], Main and Jowett Score (2 studies) [17,39], Short Form — 36 Score (2 studies)[19,34], Foot Functional Index (1 study) [34], Foot and Ankle Outcome Score (2 studies) [42,44], Kenneth Johnson Satisfaction Score (1 study) [46], and personalised questionnaires (7 studies) [10,19,36,41–44].

3.8. Return rates to sports

3.8.1. Non-operative management

The return rates for the non-operatively-managed Lisfranc injuries are provided in Table 4 and Fig. 2a.

Table 4
Summary of the return rates to sport and return times to sport by treatment modality.

Mode of treatment	$n^{(total)}$	Return rates to sport	Mean return times to sport	Return rate to pre-injury level
All [10,17–19,34–46]	366	317/366 (87%) [10,17–19,34–46]	16.0 wks [10,17,18,35,36,38–40,43,45,46]	291/366 (80%) [10,17–19,34–46]
Nonoperative [10,17,18,39,43,45]	71	68/71 (96%) [10,17,18,39,43,45]	8.7 wks [10,17,18,39,43,45]	64/71 (90%) [10,17,18,39,43,45]
Operative [17–19,34–46]	295	249/295 (84%) [17–19,34–46]	21.2 wks [17,18,35,36,38–40,43,45,46]	227/295 (77%) [17–19,34–46]
Open Reduction Internal Fixation [17,18,34,37,39–41,44,45]	139	109/139 (78%) [17,18,34,37,39–41,44,45]	19.6 wks [17,18,39,40,45]	100/139 (72%) [17,18,34,37,39–41,44,45]
Primary Partial Arthrodesis [19,40–42]	85	72/85 (85%) [19,40–42]	22.0 wks [40]	59/85 (69%) [19,40–42]
Percutaneous Reduction Internal Fixation [17,35,37,46]	42	41/42 (98%) [17,35,37,46]	11.6 wks [17,35,46]	41/42 (98%) [17,35,37,46]
Tightrope/Interosseous Suture Button [36,38]	7	7/7 (100%) [36,38]	19.4 wks [36,38]	7/7 (100%) [36,38]
Generic surgical cohorts [43]	22	20/22 (91%) [43]	46.4 wks [43]	20/22 (91%) [43]

– = No data available.

The return rates to pre-injury level sport for the non-operatively-managed Lisfranc injuries are provided in Table 4.

3.8.2. Operative management

The return rates for the various methods of operative management are provided in Table 4 and Fig. 2a.

The return rates to pre-injury level sport for the various methods of operative management are provided in Table 4.

On meta-analysis of the synthesis data, PRIF produced significantly better return rates than ORIF (OR 11.28: 95% CI 1.49–85.45, $p < 0.019$; $I^2 = 0\%$, $p = 0.52$) and PPA (OR 8.08: 95% CI 1.03–63.74, $p < 0.047$; $I^2 = N/A$). There was no significant difference found between the return rates for PPA compared to ORIF (OR 1.52: 95% CI 0.75–3.12, $p = 0.248$; $I^2 = 39\%$, $p = 0.20$).

On meta-analysis of the synthesis data, PRIF produced significantly better return rates to pre-injury level of sport than ORIF (OR 15.99: 95% CI 2.13–120.29, $p < 0.007$; $I^2 = 0\%$, $p = 0.52$) and PPA (OR 18.07: 95% CI 2.36–138.49, $p < 0.005$; $I^2 = N/A$). There was no significant difference found between the return rates for PPA compared to ORIF (OR 1.13: 95% CI 0.63–2.04, $p = 0.686$; $I^2 = 39\%$, $p = 0.20$).

3.8.3. Ligament injuries

The return rates for the different stages of ligament injuries, sub-divided by treatment method, are provided in Table 5 and Fig. 2b.

The return rates to pre-injury level of sport for the different stages of ligament injuries, sub-divided by treatment method, are provided in Table 5.

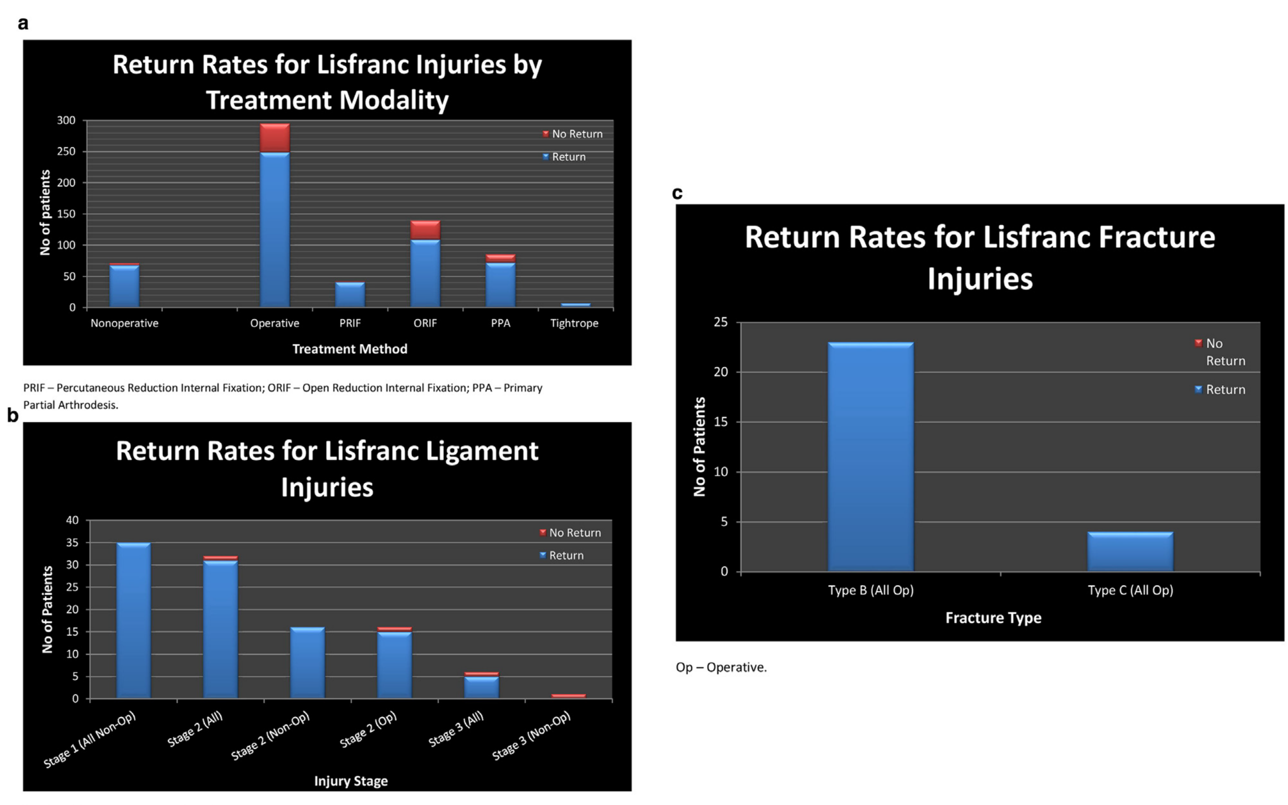

Fig. 2. (a) Return rates to sport for lisfranc injuries by treatment modality. *Note*: PRIF — Percutaneous reduction internal fixation; ORIF — Open reduction internal fixation; PPA — Primary partial arthrodesis. (b) Return rates to sport for lisfranc ligament injuries by injury stage. *Note*: Non-Op — Non-operative; Op — Operative. (c) Return rates to sport for lisfranc fracture injuries by fracture type. *Note*: Op – Operative.

Table 5
Summary of the return rates to sport and return times to sport by injury nature and treatment modality.

Mode of treatment	n(total)	Return rates to sport	Mean return times to sport	Return rate to pre-injury level
Ligaments [10,17–19,34,38–41,45,46]	191	157/191 (82%) [10,17–19,34,38–41,45,46]	8.9 wks [10,17,18,38–40,45,46]	153/191 (80%) [10,17–19,34,38–41,45,46]
Stage 1 (All Non-op) [10,17,18]	35	35/35 (100%) [10,17,18]	4.0 wks [10,17,18]	34/35 (97%) [10,17,18]
Stage 2 [10,17,18,40,45]	32	31/32 (97%) [10,17,18,40,45]	13.3 wks [10,17,18,40,45]	30/32 (94%) [10,17,18,40,45]
Stage 2 Operative [17,40,45]	16	15/16 (94%) [17,40,45]	17.4 wks [17,40,45]	15/16 (94%) [17,40,45]
Stage 2 Non-operative [10,18,45]	16	16/16 (100%) [10,18,45]	9.1 wks [10,18,45]	15/16 (94%) [10,18,45]
Generic Stage 1 & 2 (non-operative) [39]	9	7/9 (78%) [39]	11.6 wks [39]	7/9 (78%) [39]
Stage 3 [18,39]	6	5/6 (83%) [18,39]	15.5 wks [18,39]	5/6 (83%) [18,39]
Stage 3 operative [18,39]	5	5/5 (100%) [18,39]	15.5 wks [18,39]	5/5 (100%) [18,39]
Stage 3 non-operative [39]	1	0/1 (0%) [39]	–	0/1 (0%) [39]
Avulsion Fractures [38,39,46]	9	9/9 (100%) [38,39,46]	12.3 wks [38,39,46]	7/9 (78%) [38,39,46]
Avulsion Fractures Operative [38,46]	5	5/5 (100%) [38,46]	7.4 wks [38,46]	5/5 (100%) [38,46]
Avulsion Fractures Non-Operative [39]	4	4/4 (100%) [39]	18.4 wks [39]	2/4 (50%) [39]
Generic Ligament Injury [19,34,41,46]	100	70/100 (70%) [19,34,41,46]	7.7 wks [46]	70/100 (70%) [19,34,41,46]
Fractures [19,34,35,38–40]	69	60/69 (87%) [19,34,35,38–40]	18.7 wks [35,38–40]	60/69 (87%) [19,34,35,38–40]
Type B [35,38–40]	23	23/23 (100%) [35,38–40]	18.3 wks [35,38–40]	23/23 (100%) [35,38–40]
Type C [40]	4	4/4 (100%) [40]	20.5 wks [40]	4/4 (100%) [40]
Generic Fractures [19,34]	42	33/42 (79%) [19,34]	n/a	33/42 (79%) [19,34]
Generic [36,37,42–44]	106	100/106 (94%) [36,37,42–44]	41.1 wks [36,43]	78/106 (74%) [36,37,42–44]

3.8.4. Fracture injuries

The return rates for the different types of fracture injuries, sub-divided by treatment method, are provided in Table 5 and Fig. 2c.

The return rates to pre-injury level of sport for the different types of fracture injuries, sub-divided by treatment method, are provided in Table 5.

3.9. Return times to sports

3.9.1. Non-operative management

The return times for the non-operatively-managed Lisfranc injuries are provided in Table 4 and Fig. 3a.

3.9.2. Operative management

The return times for the various methods of operative management are provided in Table 4 and Fig. 3a.

On meta-analysis of the synthesis data, PRIF had significantly quicker return times than both ORIF (MD 8.1 weeks: 95% CI 5.75–10.37, $p < 0.001$); and PPA (MD 10.4 weeks: 95% CI 6.28–14.58, $p < 0.002$). There was no significant difference between the return times for PPA and ORIF (MD 2.4 weeks: 95% CI −1.96 to 6.72, $p = 0.478$).

3.9.3. Ligament injuries

The return times for the different stages of ligament injuries, sub-divided by treatment method, are provided in Table 5 and Fig. 3b.

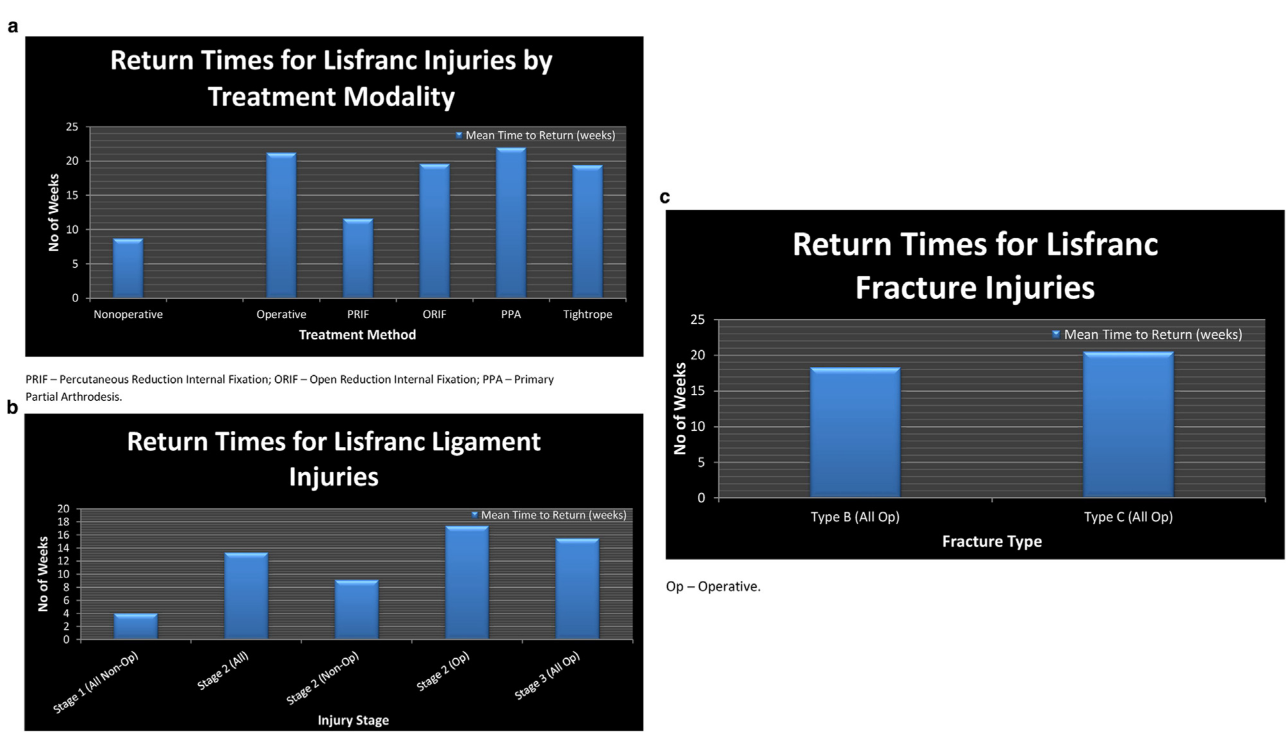

Fig. 3. (a) Return times to sport for lisfranc injuries by treatment modality. *Note*: PRIF — Percutaneous reduction internal fixation; ORIF — Open reduction internal fixation; PPA — Primary partial arthrodesis. (b) Return times to sport for lisfranc ligament injuries by injury stage. *Note*: Non-Op — Non-operative; Op — Operative. (c) Return times to sport for lisfranc fracture injuries by fracture type. *Note*: Op — Operative.

3.9.4. Fracture injuries

The return times for the different types of fracture injuries, sub-divided by treatment method, are provided in Table 5 and Fig. 3c.

3.10. Radiographic union

Three studies reported on radiographic union [38,41,42], with two recording union rates [38,42] and one recording union times [41]. Rates of union were recorded at 100% [38,42] and mean time to union at 10.6 weeks [41].

3.11. Maintenance of post-operative reduction

Maintenance rates of post-operative reduction were reported by six studies [17,19,34,40,42,46]. Four studies recorded a 100% rate of maintained reduction [17,40,42,46]; the cohorts comprised a combination of PRIF, ORIF and PPA. One study using ORIF reported a rate of maintained reduction of 88% [34] (ligamentous injuries 89%; fracture injuries 86%); another study using PPA reported an 'anatomic' rate of 48%, a 'near-anatomic' rate of 40% and a 'non-anatomic' rate of 12% [19].

3.12. Complications

3.12.1. Non-operative management

For the non-operatively-managed Lisfranc injuries, the reported complications included delayed arthrodesis (7% [39]), recurrence of injury (17% [10]) (Table 2). Two of the six studies reported complications [10,39].

3.12.2. Operative management

For the Lisfranc injuries managed with ORIF, the reported complications included malunion (12–75% [34,41]), conversion to arthrodesis (3–25% [34,41]), removal of symptomatic metalwork (40–80% [39,41]), transient paraesthesia (13% [40]), persistent paraesthesia (7% [40]). Routine removal of metalwork was performed in five studies [18,34,40,44,45]. Four of the nine studies reported complications [34,39–41].

For the Lisfranc injuries managed with PPA, the reported complications included removal of symptomatic metalwork (10–16% [19,41,42]), delayed union (5% [41]), revision arthrodesis for non-union (5–8% [19,41]), compartment syndrome (5%) [41]. Routine removal of metalwork was performed in one study [40]. Three of the four studies reported complications [19,41,42].

For the Lisfranc injuries managed with PRIF, the reported complications were removal of symptomatic metalwork (14% [46]), transient paraesthesia (5% [46]) and revision ORIF (100% [37]). One study performed routine removal of metalwork [35]. Two of the four studies reported complications [37,46].

For the Lisfranc injuries managed with TightRope/Interosseous Suture Button, there were no complications reported in either of the two studies [36,38].

3.13. Predictive factors

One study found no significant difference in return rates to sport between ligamentous injuries (75%) and fracture injuries (83%) ($p = 0.28$) [34].

However, another study found a significant difference in the mean time to return to competitive sport between primarily ligamentous (22.5 weeks) and fracture injuries (26.9 weeks) ($p < 0.003$) [40]. The same study also found a significant difference in the return to competitive sport between rugby (27.8 weeks) and soccer players (24.1 weeks; $p = 0.02$) [40].

A randomised controlled trial between ORIF and PPA found that PPA (71%) had improved return rates to sport compared to ORIF (30%) [41].

In another study, players treated non-operatively exhibited a trend toward earlier return to play (median absence from play of 6.2 (IQR, 1.9–10.7) months) compared with those treated operatively (median absence from play of 11.6 (IQR, 10.7–12.6) months) ($p < 0.02$) [43].

Finally, a study recording outcomes on non-operatively-managed ligamentous injuries found a significant difference in mean (SD) return time between Stage 1 sprains (mean 3.1 (1.9) days), and Stage 2 sprains (mean 36 (26.1) days) ($p < 0.047$) [18].

4. Discussion

The main findings of this review are that most patients with a Lisfranc injury will return to sport, with 80% of patients able to return to their pre-injury level of sport. Non-operative management of undisplaced and stable minimally-displaced (diastasis 2–5 mm) injuries provided good results for return to pre-injury level of sport, with return rates as high as 100%. Of the operative techniques, PRIF provided the best return times and return rates for low-energy injury patterns. For high-energy injury patterns, there was no significant difference between the return rates and return times for ORIF compared to PPA.

While the methodological quality of the studies in this review was relatively high compared to previous similar reviews [25–30], there was only one RCT, with the rest of the included studies Level 3 or 4 evidence. This demonstrates a requirement for further high quality research in this field.

Non-operative management provided good return rates and return times to sport for both undisplaced injuries (RR 100%; RT 4.0 weeks) and stable minimally-displaced injuries (RR 100%; RT 9.1 weeks). As such, non-operative management would appear to be an acceptable treatment for both these injury types [1,18]. Despite this, the management of stable minimally-displaced injuries remains a controversial subject, with 53% of National Football League Team Physicians recommending non-operative management of these, while 47% recommend operative management [18]. Further research is required to define the optimal management of this injury type, particularly to determine the longer term outcome following this [18].

Operative management of displaced and unstable minimally-displaced Lisfranc injuries offered good return rates (84%) and return times (21.2 weeks). The strongest evidence was available for ORIF ($n = 139$), PPA ($n = 85$) and PRIF ($n = 42$). Of these techniques, PRIF offered the quickest return times (11.6 weeks), and the highest return rates (98%): this technique however was only suitable for low-energy injury patterns [17,35,37,46]. No significant difference was found between the return rates (78% vs 85%) and return times (19.6 weeks vs 22.0 weeks) between ORIF and PPA for the higher energy injury patterns. The improved return rates and times with PRIF are likely explained by: the lower energy injury patterns amenable to this technique; the reduced tissue dissection with this procedure; and the accelerated rehabilitation programme that can be adopted following this technique [17,35,37,46]. There remains controversy over whether ORIF or PPA is the better treatment option for higher energy injury patterns [41,47,48]. While Level 1 evidence shows PPA to offer a better return rate to sport [41], two systematic reviews have found limited significant differences in the outcome between the two techniques [47,48]. Further well-designed RCTs are required to determine the answer [47,48].

In comparison to previous studies, there was good reporting of both rehabilitation methods and functional outcome scores [25–30]. Fifteen studies reported rehabilitation protocols, with the majority providing comprehensive descriptions of weight-bearing status and duration, immobilisation method and time to commence physiotherapy [10,17–19,34–36,38–42,44–46]. Eleven studies used formal validated scoring methods to allow assessment of post-treatment function [10,17,19,34,36,39,41–44,46].

A review of the rehabilitation methods used, particularly within treatment categories, revealed considerable variation in this field [10,17–19,34–36,38–42,44–46]. With the numbers available, it was not possible to assess the effect of variation in rehabilitation methods. It was, however, noted that the best return times were from a study which allowed accelerated weight-bearing, in a cohort of low-energy Lisfranc injuries treated with PRIF [46]. Appreciably, this will not be possible with the higher energy injury patterns, managed with PPA and ORIF [1–5]. However, with the wide variations present, particularly with regards time to commence weight-bearing and physiotherapy, efforts should be made to refine and optimise rehabilitation protocols in future studies [1–5].

There are several limitations to this review.

The first relates to the reporting of return rates and times to sport throughout the studies. While it was possible to record return rates, return times and return to pre-injury level of sport from most studies, few studies provided comprehensive descriptions of sporting outcome, particularly with regard to the different times taken for the different stages in the return process. Such information would have allowed the review to provide a more detailed description of the recovery process. To provide clear comparison data from the pooled cohort, sporting outcome was categorised into three main divisions (return to sport, return to same level of sport, return time to sport).

The second limitation relates to the heterogeneity of the Lisfranc injury cohort, comprising a wide variety of injury types [10,17–19,34–46]. In many series, the diagnostic category is limited to ligament, fracture or generalised Lisfranc injury, and this can limit the ability to differentiate between injuries of differing severity and nature. To obviate against this, the authors have categorised the injuries, where possible, into ligament and fracture injuries, and sub-divided these by grading of injury, allowing a more accurate perspective of predicted outcome for each type of injury [10,17–19,34–46].

Lastly, due to the limited size of certain sub-cohorts within the synthesis data, it was only possible to perform three meta-analysis comparisons (return rates, return times, return rates to pre-injury level of sport): comparisons between outcomes for the various methods of conservative management, as well as between outcomes of different injury severity was not possible given their limited sub-cohort size. The limited sub-cohort sizes also prevented the results of each sub-cohort to be stratified for patient demographics, nature of injury and severity of injury. While this would have been preferable, to provide more detailed results, unfortunately this was a limitation of the available study data.

5. Conclusion

Most athletes who suffer a Lisfranc injury can expect to return to sport. Non-operative management forms the recommended treatment for all undisplaced and stable minimally-displaced Lisfranc injuries. Operative management should be recommended for all unstable minimally-displaced and displaced injuries. The choice of operative procedure is directed by the configuration of the injury. For low-energy injuries, PRIF provides the best return rates and quickest return to sport. For higher energy injuries, there is no significant difference in return rates or return times between PPA and ORIF.

Acknowledgements

None to note.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

None.

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