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Open Reduction and Internal Fixation Versus Primary Arthrodesis for the Treatment of Acute Lisfranc Injuries: A Systematic Review and Meta-analysis

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ABSTRACT

This study aims to compare outcomes of open reduction and internal fixation (ORIF) and primary arthrodesis in management of Lisfranc injuries. In accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement standards, a systematic review was carried out. MEDLINE, EMBASE, CINAHL, and the Cochrane Central Register of Controlled Trials were searched to identify both randomised controlled trials (RCTs) and nonrandomised studies comparing the outcomes of ORIF and primary arthrodesis for Lisfranc injuries. Random- and fixed-effect statistical models were applied to calculate the pooled outcome data. Two RCTs and 3 observational studies were identified, compiling a total of 187 subjects with acute Lisfranc injuries and a mean follow-up duration of 62.3 months. Our results demonstrate that ORIF is associated with a significantly higher need for revision surgery (odds ratio [OR] 6.37, 95% confidence interval [CI] 2.68 to 15.11, $p < .0001$) and a significantly higher rate of persistent pain (OR 6.29, 95% CI 1.07 to 36.89, $p = .04$) compared with primary arthrodesis. However, we found no significant difference between the groups in terms of visual analogue scale pain score, American Orthopaedic Foot & Ankle Society functional score, or rates of infection. Separate analysis of RCTs showed that ORIF was associated with a more frequent need for revision surgery (OR 17.56, 95% CI 5.47 to 56.38, $p < .00001$), higher visual analogue scale pain score (mean difference 2.90, 95% CI 2.84 to 2.96, $p < .00001$), and lower American Orthopaedic Foot & Ankle Society score (mean difference −29.80, 95% CI −39.82 to −19.78, $p < .00001$). The results of the current study suggest that primary arthrodesis may be associated with better pain and functional outcomes and lower need for revision surgery compared with ORIF. The available evidence is limited and is not adequately robust to make explicit conclusions. The current literature requires high-quality and adequately powered RCTs.

Lisfranc injuries (tarsometatarsal dislocations or fracture dislocations) are relatively uncommon, with an incidence of ~0.2% of all fractures (1). The injury is commonly missed or diagnosed late (2) and often leads to pain (3), poor functional outcomes (4), and chronic disability (3). Currently, the most accepted and recognised treatment modality remains open reduction and internal fixation (ORIF) (5). However, in some cases, this results in painful osteoarthritis and conversion to arthrodesis is required as a salvage procedure (6,7).

Recent research has proposed the use of primary arthrodesis of the involved tarsometatarsal joints as a means of definite treatment (5,8). Presently, open reduction, internal fixation, and primary arthrodesis are common approaches to the management of acute Lisfranc injuries. Controversy exists whether ORIF or primary fusion results in better surgical outcomes; a systematic review in 2012 included only 2 randomised controlled trails and concluded that no benefit of one approach over the other could be found (9).

In this article, the outcomes of ORIF and primary fusion have been compared in numerous studies in recent years, making meta-analyses worthwhile. Our objective is to perform a systematic review of the literature and a meta-analysis to investigate the outcomes.

Materials and Methods

This systematic review was carried out in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards (10).

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Conflict of Interest: None reported.
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Eligibility Criteria

We aimed to include all randomised controlled trials (RCTs) and observational studies comparing the outcomes of ORIF and primary arthrodesis for Lisfranc injuries. The Lisfranc injury was considered the condition of interest, ORIF was considered the intervention of interest, and primary arthrodesis was considered the comparison of interest.

Outcome Measures

Five specific outcome measures were measured: need for revision surgery, visual analogue scale (VAS) pain score, postoperative infection, chronic pain, and American Orthopaedic Foot & Ankle Society (AOFAS) functional score.

Literature Search Strategy

Two independent co-authors (H.M., S.H.) searched MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials, and CINAHL. The most recent search was run on August 7, 2017. All relevant articles and reviews were thoroughly reviewed for further potentially suitable papers. The literature search was not restricted to the English language. The literature search strategy is outlined in the Appendix.

Study Selection

Two authors independently assessed the title and abstract of all articles identified from the initial literature search. The full texts of applicable papers were evaluated; studies that met the eligibility criteria of this review were chosen. An additional, and independent, third author was involved in the event of any discrepancy of papers within the study selection.

Data Collection

A data extraction spreadsheet was created in accordance with Cochrane's data collection criteria for intervention reviews. The database included study-related data (authors, country of origin, year of publication, published journal, methodology, and population size). Demographics and clinical information of the study populations was also recorded (age, sex, and duration of follow-up). All outcome measures were recorded. The data extraction was performed by 2 independent co-authors, and any inconsistencies were resolved by thorough examination of the published figures. A third, and independent, author was consulted in the case of any disagreement.

Data Synthesis and Statistical Analysis

All dichotomous outcome variables (need for revision, persistent pain, and postoperative infection) were analysed using an odds ratio (OR). The OR describes the odds of a particular outcome in the ORIF group versus the primary fusion group. For each complication, an OR of >1 would therefore favour the primary fusion group. For continuous parameters (VAS score and AOFAS score), the mean difference (MD) between ORIF and primary fusion groups was calculated.

Review Manager 5.3 software (Cochrane Community, Oxford, UK) was used for the data synthesis and analysis. Random- and fixed-effect modelling were applied as appropriate. A random-effects model was applied only if considerable heterogeneity existed between the studies. Results were displayed in a forest plot using 95% confidence intervals (CIs). We measured inconsistency by calculating the I^2 (where 0% to 25% suggests low heterogeneity, 25% to 75% suggests moderate heterogeneity, and 75% to 100% suggests high heterogeneity).

Methodologic Quality and Risk of Bias Assessment

Two independent co-authors each evaluated all the included articles using the Cochrane tool and Newcastle-Ottawa Scale to assess the risk of bias. The Cochrane tool analyses bias that exists in RCTs in domains including selection, attrition, and reporting. The Newcastle-Ottawa Scale implements a 1-star (lowest risk) to 9-star (highest risk) system to assess the quality of each study in terms of the comparability of the groups, the selection of the study groups, and the ascertainment of outcome of interest. A third, and independent, author was consulted in the case of any disagreement.

Sensitivity Analyses

Sensitivity analysis was carried out to investigate possible sources of heterogeneity and evaluate the strength of our data. For each outcome parameter, we carried out both random- and fixed-effect models. Additionally, we performed analysis to include both risk ratio and risk difference applicable to each dichotomous outcome. To assess the effect that each study had on the overall effect size and heterogeneity, the statistical analysis was carried out repeatedly after removing each study individually.

Results

Literature Search Results

The literature search identified 1307 articles, of which 5 were eligible for inclusion (Fig. 1). This included 2 RCTs (11,12) and 3 retrospective cohort studies (8,13,14). In total, these articles involved 187 subjects with acute Lisfranc Injuries and a mean follow-up duration of 62.3 months. Overall, 117 subjects underwent ORIF, and 70 underwent primary fusion. The basic characteristics of all included studies are presented in the Table.

Methodologic Quality and Risk of Bias

The outcomes of the methodologic quality assessment of the 3 observational studies and 2 RCTs are demonstrated graphically in Fig. 2.

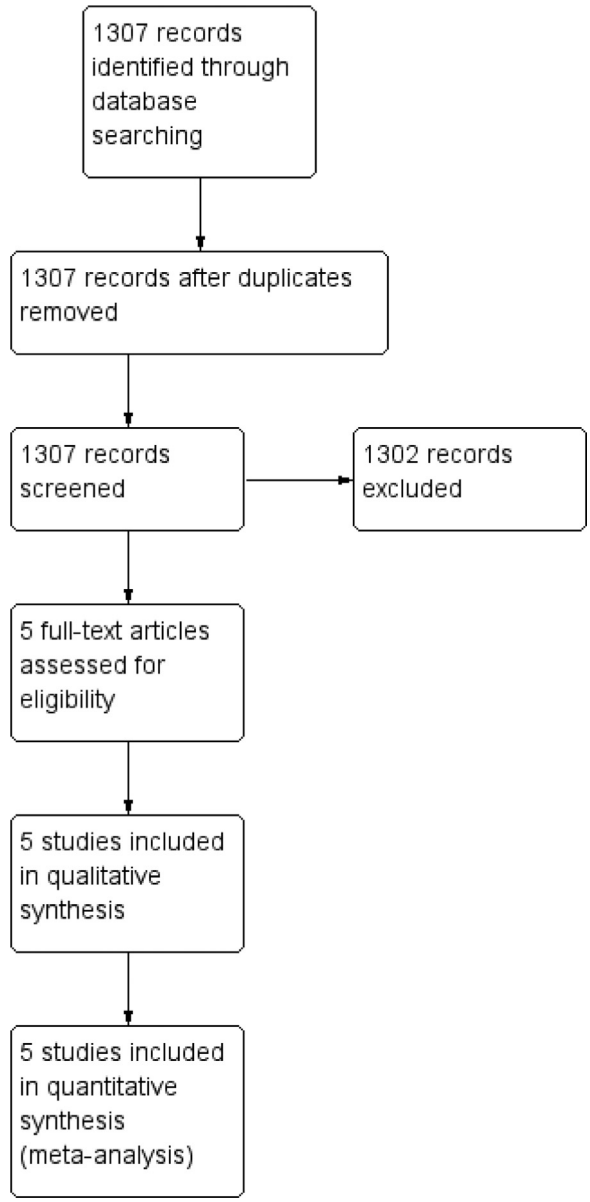


Fig. 1. Study flow diagram.

Table
Baseline characteristics of the included studies

Country	Journal	Study Design	Follow-Up (months)	Sample Size	ORIF	Primary Arthrodesis	Mean Age (years)	% Male
Geneva, Switzerland (13)	*Journal of Bone and Joint Surgery*	Retrospective	130.9	61	50	11	37.5	78.7
Michigan, USA (11)	*Foot & Ankle International*	RCT Prospective	24	32	14	18	NA	65.7
Leuven, Belgium (5)	*Foot & Ankle International*	Retrospective	30.1	28	16	12	30.5	NA
Soochow, China (14)	*Chinese Orthopedic Association*	Retrospective	15	25	17	8	39	68
Minnesota, USA (12)	*Journal of Bone Joint Surgery*	RCT Prospective	42.5	41	20	21	32	NA

Abbreviations: NA, not available; ORIF, open reduction and internal fixation; RCT, randomised controlled trial; USA, United States of America.

Outcome: Need for Revision Surgery

The requirement for revision surgery was reported in 4 studies (8,11,12,14) involving 126 subjects (Fig. 3). The need for revision was significantly higher in the ORIF group (OR 6.37, 95% CI 2.68 to 15.11, $p < .0001$). A moderate level of heterogeneity among the studies existed ($I^2 = 61\%$, $p = .05$).

Outcome: VAS Pain Score

The VAS pain score was recorded in 3 studies (12–14) involving 127 subjects (Fig. 3). There was no significant difference in the VAS score between the ORIF and primary arthrodesis groups (MD 1.37, 95% CI −0.51 to 3.25, $p = .15$). A high level of heterogeneity among the studies existed ($I^2 = 96\%$, $p < .00001$).

Outcome: AOFAS Score

AOFAS score was reported in 3 studies (12–14) involving 127 subjects (Fig. 3). There was no significant difference in the AOFAS score between the ORIF and primary arthrodesis groups (MD −10.91, 95% CI −27.08 to 5.26, $p = .19$). A high level of heterogeneity among the studies existed ($I^2 = 91\%$, $p < .0001$).

Outcome: Persistent Pain

Persistent pain was reported in 2 studies (12,14) involving 66 subjects (Fig. 3). Persistent pain was significantly higher in the ORIF group compared with the primary arthrodesis group (OR 6.29, 95% CI 1.07 to 36.89, $p = .04$). A low level of heterogeneity among the studies existed ($I^2 = 0\%$, $p = .38$).

Outcome: Postoperative Infection

Postoperative infection was reported in 2 studies (13,14) involving 86 subjects (Fig. 3). There was no significant difference in postoperative infection between the ORIF and primary arthrodesis groups (OR 1.34, 95% CI 0.14 to 13.00, $p = .80$). A low level of heterogeneity among the studies existed ($I^2 = 0\%$, $p = .91$).

Sensitivity Analyses

We performed sensitivity analyses for the need for revision surgery, which was reported in 4 studies (8,11,12,14). The use of random- or fixed-effect models did not affect the direction of the effect size. Moreover, the direction of the effect size remained unchanged when risk ratios or risk differences were calculated. The

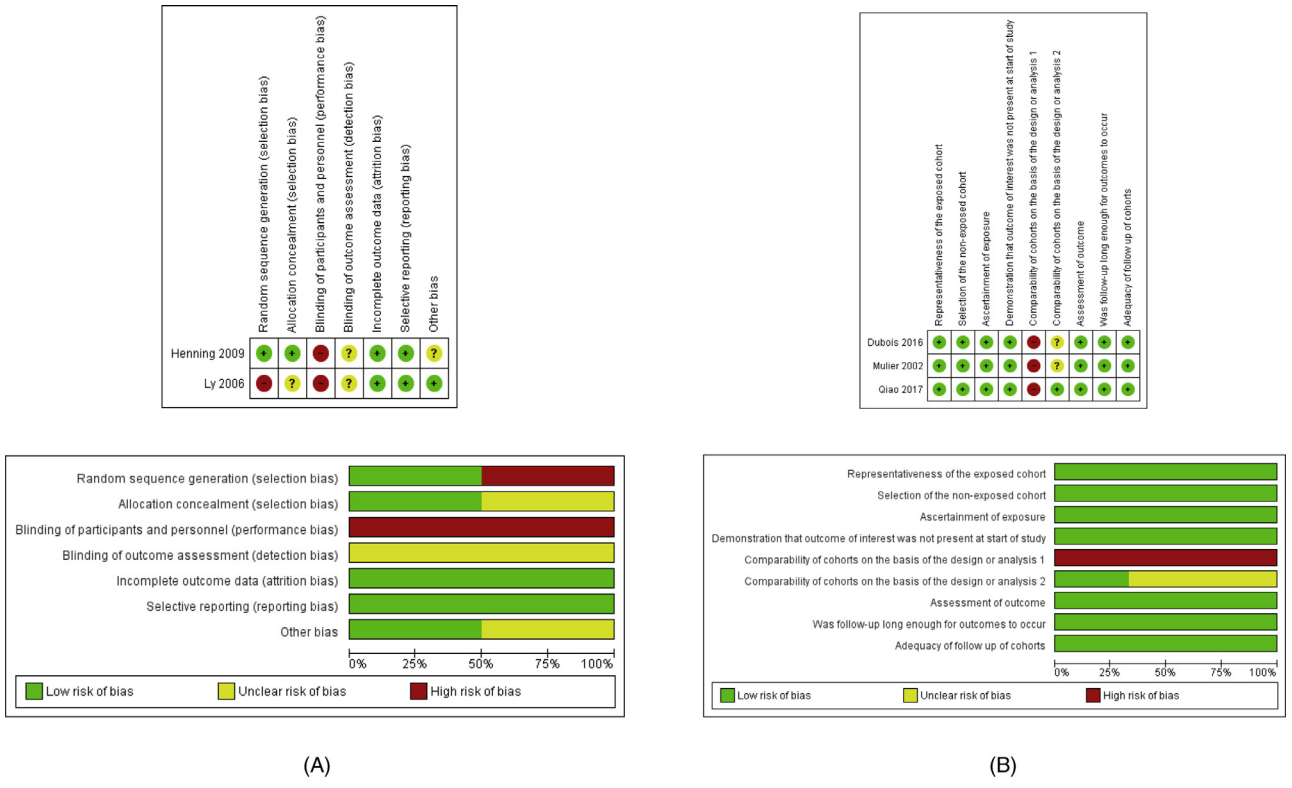
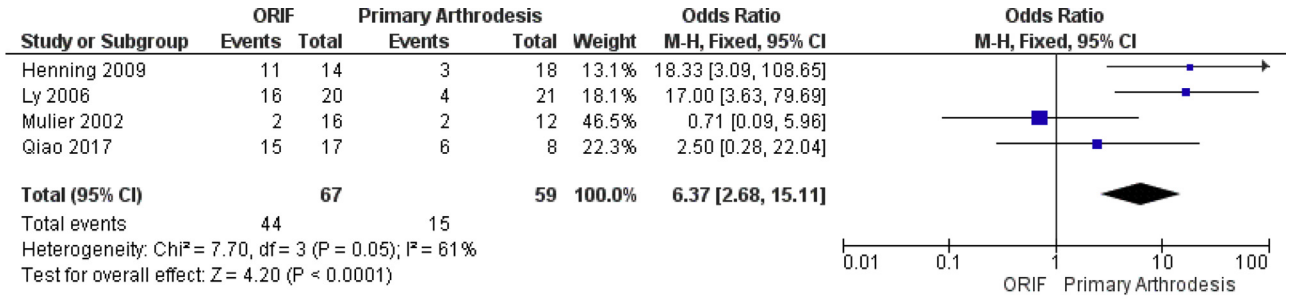
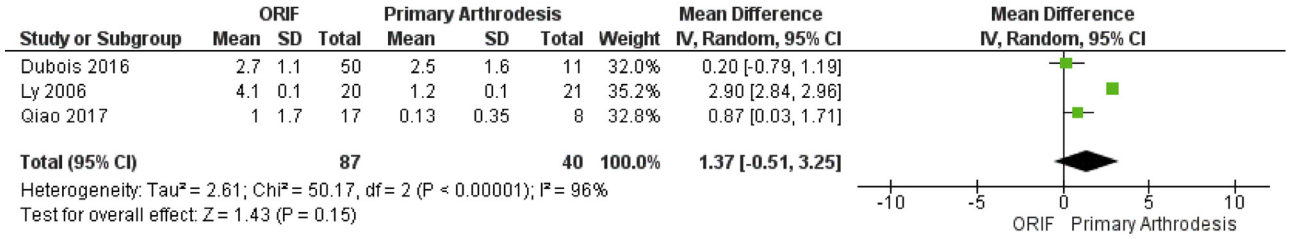


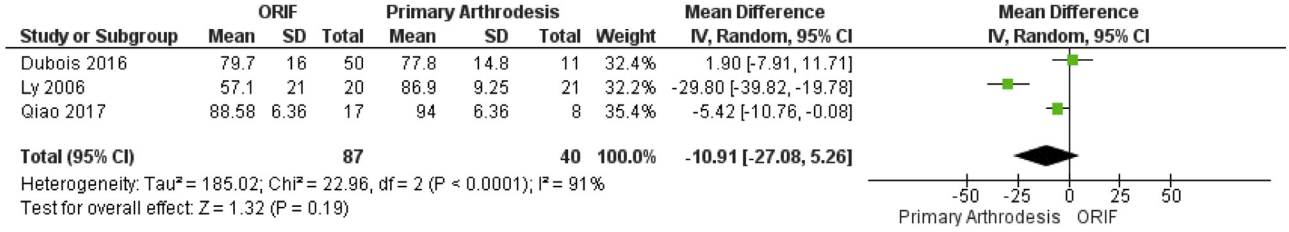
Fig. 2. Risk of bias summary and graph showing authors' judgements about each risk of bias item for randomised trials (*A*) and observational studies (*B*).



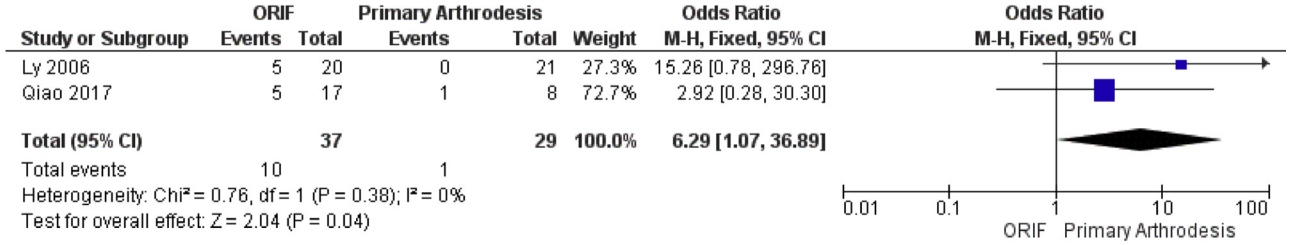
(A) Need for revision surgery



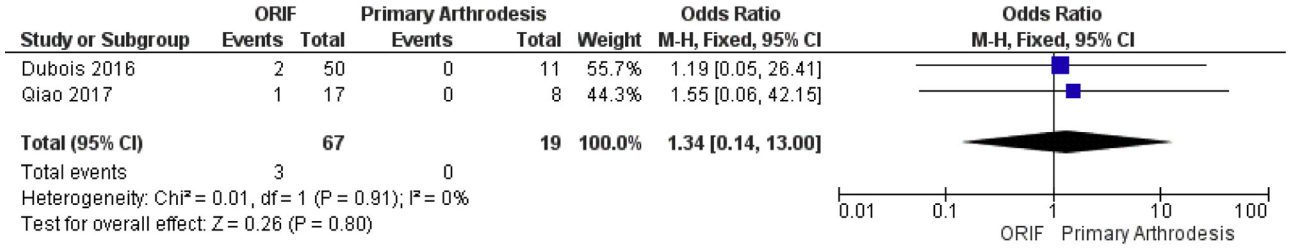
(B) VAS score



(C) AOFAS



(D) Persistent pain



(E) Post-operative infection

Fig. 3. Forest plots of the comparisons of need for revision surgery (*A*), visual analogue scale (VAS) score (*B*), American Orthopaedic Foot & Ankle Society (AOFAS) score (*C*), persistent pain (*D*), and postoperative infection (*E*). Abbreviations: CI, confidence interval; IV, independent variable; M-H, Mantel-Haenszel; ORIF, open reduction and internal fixation.

separate analyses for studies with low or moderate risk of bias did not affect the direction of the effect size. Removing 1 study at a time did not change the direction of the effect size.

Randomised Controlled Trials

Two RCTs involving 73 subjects were included. ORIF was associated with more frequent need for revision surgery (OR 17.56, 95% CI 5.47 to 56.38, $p < .00001$), higher VAS pain score (MD 2.90, 95% CI 2.84 to 2.96, $p < .00001$), and lower AOFAS score (MD −29.80, 95% CI −39.82 to −19.78, $p < .00001$) compared with primary arthrodesis. There was no difference between ORIF and primary arthrodesis in persistent pain (OR 15.26, 95% CI 0.78 to 296.76, $p = .07$).

Discussion

We performed a systematic review of the literature and meta-analysis of reported outcomes for ORIF and primary arthrodesis in management of acute Lisfranc injuries. We included 2 RCTs and 3 retrospective observational studies, enrolling a total of 187 subjects. Our meta-analysis is the most up-to-date review in the literature. Our analyses suggested that ORIF is associated with higher rates of need for revision surgery and persistent pain compared with primary arthrodesis. We found no difference in VAS pain score, AOFAS functional score, or rates of infection between the 2 treatments. The between-study heterogeneity was moderate to high, and the quality of available evidence was low to moderate.

Smith et al (15) reported similar findings in a recent meta-analysis involving only 3 of the 5 studies included in this study (8,11,12). Their meta-analysis revealed a high rate of further surgery, with a risk ratio of 0.23 (95% CI 0.11 to 0.45; $p < .001$); however, this finding was not observed when simple hardware removal was excluded. In addition, Smith et al (15) also observed no significant difference between the groups with regard to the AOFAS functional score. Our study is currently the most comprehensive systematic review (n = 187) in the literature. We have included further outcome measures in relation to persistent pain and infection rates.

In the current literature, Lisfranc injuries usually encompass a range of pathologies from simple ligament tears to open fracture dislocations. This may account for the large variability in the data observed. Lack of data appears to be the largest limitation of the meta-analysis; a larger body of high-quality evidence is therefore required to independently analyse the severity of pathologies and subsequent outcomes of management options.

With regard to revision surgery, it is important to note that in the study by Henning et al (11), the surgical preference post-ORIF was to remove metalwork regardless of symptomatology (3 subjects refused removal); this therefore results in a degree of bias in the analysis. Additionally, data for complex or multistage revision surgery that may have significant impact on quality of life were not recorded and may not be relevant given the subject population size. Such data would provide patients and surgeons with a useful tool to influence the choice of surgery. However, the low incidence and high rate of misdiagnosis of Lisfranc injuries make large studies difficult. Further high-quality comparative evidence and subsequent meta-analysis is required on the subject.

The reported outcomes of our review and analysis should be viewed and interpreted in the context of inherent limitations. We identified a limited number of eligible studies reporting a relatively small number of patients. All of the outcomes were reported by a very limited number of studies; therefore, the low number of participants and events might have led to imprecise effects estimates, reflected by wide confidence intervals for the calculated summary measures.

In conclusion, the results of current study suggest that primary arthrodesis may be associated with better pain and functional outcomes and lower need for revision surgery compared with ORIF. The available evidence is limited and is not adequately robust to make definite conclusions. The current literature requires high-quality and adequately powered RCTs.

Supplementary Materials

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1053/j.jfas.2018.08.061.

References

1. Aitken AP, Poulson D. Dislocation of the tarsometatarsal joint. J Bone Joint Surg Am 1963;45:246–260.
2. Pinzur MS, Lomasney L, Mahoney L, Havey R. Functional outcome following anatomic restoration of tarsal-metatarsal fracture dislocation. Foot Ankle Int 2002;23:922–926.
3. Buzzard BM, Briggs PJ. Surgical management of acute tarsometatarsal fracture dislocation in adult. Clin Orthop Relat Res 1998;353:125–133.
4. Desmond EA, Chou LB. Current concepts review: Lisfranc injuries. Foot Ankle Int 2006;27:653–660.
5. Mulier T, Reynders P, Dereymaeker G, Broos P. Severe Lisfrancs injuries: primary arthrodesis or ORIF? Foot Ankle Int 2002;23:902–905.
6. Hardcastle PH, Reschauer R, Kutscha-Lissberg E, Schoffmann W. Injuries to the tarsometatarsal joint. J Bone Joint Surg Br 1982;64:349–356.
7. Komenda GA, Myerson MS, Biddinger KR. Results of arthrodesis of the tarsometatarsal joints after traumatic injury. J Bone Joint Surg Am 1996;78:1665–1676.
8. Kuo RS, Tejwani NC, Digiovanni CW, Holt SK, Benirschke SK, Hansen Jr ST, Sangeorzan BJ. Outcome after open reduction and internal fixation of Lisfranc joint injuries. J Bone Joint Surg Am 2000;82:1609–1618.
9. Lewis C, Mauffrey C, Dickenson E. Open reduction and internal fixation compared with primary arthrodesis of Lisfranc injuries: a systematic review of the literature. Curr Orthop Pract 2012;23:595–600.
10. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JPA, Clarke M, Devereaux PJ, Kleijnen J, Moher D. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 2009;339:b2700.
11. Henning JA, Jones CB, Sietsema DL, Bohay DR, Anderson JG. Open reduction internal fixation versus primary arthrodesis for Lisfranc injuries: a prospective randomized study. Foot Ankle Int 2009;30:913–922.
12. Ly TV, Coetzee JC. Treatment of primarily ligamentous Lisfranc joint injuries: primary arthrodesis compared with open reduction and internal fixation. J Bone Joint Surg Am 2006;88:514–520.
13. Dubois-Ferrière V, Lübbeke A, Chowdhary A, Stern R, Dominguez D, Assal M. Clinical outcomes and development of symptomatic osteoarthritis 2 to 24 years after surgical treatment of tarsometatarsal joint complex injuries. J Bone Joint Surg Am 2016; 98:713–720.
14. Qiao YS, Li JK, Shen H, Bao HY, Jiang M, Liu Y, Kapadia W, Zhang HT, Yang HL. Comparison of arthrodesis and non-fusion to treat Lisfranc injuries. Orthop Surg 2017;9:62–68.
15. Smith N, Stone C, Furey A. Does open reduction and internal fixation versus primary arthrodesis improve patient outcomes for Lisfranc trauma? a systematic review and meta-analysis. Clin Orthop Relat Res. 2016;474:1445–1452.