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Research article

Definitive Treatments for Lisfranc Injury: A Systematic Review and Meta-Analysis

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Abstract

To prevent the risk of post traumatic long term sequelae of Lisfranc injury early recognition and expeditious surgical interventions are essence of need. There have been two contemplated ways of intervention, Open Reduction and Internal Fixation (ORIF) and Arthrodesis. Still, argument remains for better approach.

In this study, a comprehensive search was carried out on PubMed, Web of Science, Cochrane database Library, EMBASE and google scholar for studies on surgical treatment of tarsometatarsal/lisfranc injury advocated on (a) anatomic alignment (b) postoperative complication (c) re-surgery after postoperative complication (d) implant removal and (e) clinical outcome. A meta-analysis was performed by the help of basic guidelines of Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA).

Four potential studies with 146 patient were included in current meta-analysis. None of the proposed surgery had better outcome with nonanatomic alignment, the risk ratio 1.01 [95% CI, 0.92, 1.12; Test for overall effect: Z = 0.26 (P = 0.80)]. Here risk ratio for postoperative complication was 1.31 [95% CI, 0.78, 2.20; Test for overall effect: Z = 1.04 (P = 0.30)] indicating favoring neither ORIF nor arthrodesis. In the same way risk ratio for re-surgery for postoperative complication was 0.39 [95% CI, 0.12, 1.26; Test for overall effect: Z = 1.58 (P = 0.11)]. For implant removal risk ratio was calculated to be 0.14 [95% CI, 0.04, 0.50 Test for overall effect: Z = 3.05 (P = 0.002)], which indicates frequency of hardware removal was significantly soar on ORIF group while in arthrodesis it was quite low. Statistically clinical outcome of standard mean difference was 0.54 [95% CI, -1.97, 3.05 Test for overall effect: Z = 0.42 (P = 0.67)], which indicates none of intervention was on favor.

Based on the currently available statistical analysis, it was justice on the favor of arthrodesis for Lisfranc injuries in terms of anatomical alignment, implant removal, or outcome score. Arthrodesis was comparatively more beneficial for severe Lisfranc injury with complete ligamentous involvement. For further more improvements prospective randomized controlled trial will be needed with American Orthopedic Foot & Ankle Society (AOFAS) score.

Keywords: Lisfranc injury, tarsometatarsal, fracture dislocation, arthrodesis, open reduction & internal fixation, meta-analysis

Level of evidence: Level I, therapeutic study.

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Introduction

Fracture and Fracture/dislocation to Tarsometatarsal/Lisfranc joints are devastating and can be associated with long term disability, which leads to worse the expectancy of life quality due to painful post traumatic osteoarthritis and sequelae of deformity [1-10]. Lisfranc injury is limited to approximately 0.2% of total orthopedic limb trauma. It is estimated that 20% to 40% of cases are being misdiagnosed or overlooked due to lack of appearance of complex anatomical structure, which results in poor functional outcome and worsen the quality of life of the patient. Deformities vary according to severity of acute onset of injury and most common late deformities are planus or planovalgus resulting into malfunction of forefoot. Increased risk to this injury is due to high velocity activities, more the participation more is the chance of injury to Tarsometatarsal joint [6, 11-14]. Obvious that "It is worse to sprain an ankle than to break it" and is absolutely right [15]. It is concluded that anatomic reduction and fixed stabilization by means of implant is proven efficacious treatment of this injury which includes open reduction and internal fixation (ORIF) and alternative to ORIF is arthrodesis as a proven surgical intervention since a decade [16-20].

Though controversy remains among the method of most favorable approach which has least post-operative complication and best outcome. A qualitative systematic review was performed in 2012 by using Fishers exact test which demonstrated both procedures were equally effective for the American Orthopedic Foot and Ankle Society Score (AOFAS), even though sample size of study was inadequate so further prospective trials with direct comparison advised [21].

In present study, all the findings of different independent studies were pooled to find out a definitive treatment for Lisfranc injury by meta-analysis. This analysis can help to resolve the controversies of the treatment plan of the patient qualify appropriate treatment based on clinical improvement and minimizing complication of outcome with arthrodesis compared with ORIF in the provision of (a) anatomic alignment (b) postoperative complication (c) re-surgery after postoperative complication (d) implant removal (e) clinical outcome. To support the current meta-analysis, we have included some grey articles to measure outcome score.

Materials and Methods

Selection strategy and criteria

Prospective Comparative Study (PCS), Comparative Cohort Study (CCS) and Randomized Control Trial (RCT) studies in human are included and evaluation of outcome of arthrodesis in comparison with ORIF. Potential selected studies are both English and non-English, which can be translated. Potential Citations were screened at title/abstract level and retrieved as abstract as well full reports.

Statistical analysis

The included data were analyzed according to the intensions of treatment procedures by using Review Manager 5.1 version 32 bit software on windows(10) supporting operating system. P value <0.05 was considered to be statistically significant. Risk ratios (RRs) and 95% Confidence Intervals (Cis) were used as summary statistics. Heterogeneity was assessed among the studies initially by graphically examining the forest plots and subsequently by statistical evaluation using a chi square test of homogeneity and evaluation of the inconsistency index(I^2) statistic, which quantifies the percentage of variation in study results that is due to heterogeneity rather than chance. Pooled Risk Ratio (RR) was calculated using a Random effect model with the Mantel Haenszel method. Discrete variables were extracted by using risk ratio, whereas continuous variables were analyzed with standard mean difference. The Der Simonian and Laird random effects model was used in case of significant heterogeneity and/or moderate or significant inconsistency (I^2>50%) across studies.

Data extraction and quality assessment

Data of the current study was collected from 4 potential studies, extracted independently by two authors (Sah Sanjaya, Zhang Mingzhu) using predefined standardized data extraction design form. Discrepancies were resolved by consulting third investigator (Professor Yu Guangrong). Corresponding/first author were contacted through E-mail in condition in which the data regarding our outcome of the interest were likely to have been analyzed although they were not clearly reported. The following data were extracted from the included article: the first author, Study design, Sample size, interventions (arthrodesis/ORIF), Blinding, method of outcome measures. The following outcomes were analyzed to assess anatomic alignment, postoperative complication, re-surgery after postoperative complication, implant removal and clinical outcome. The quality of the included studies was rated by using United State Preventive Task Force (USPSTF).

Literature search and data source

Studies were identified through a comprehensive computerized electronic web search in PubMed, Web of Science, EMBASE, Cochrane database Library and google scholar for studies on surgical treatment of tarsometatarsal/lisfranc were performed in July 2015. We have no restrictions on search engine for dates because these methods are being used since couple of decades. We used all possible combinations of Medical Subject Headings and Title Abstracts keywords (tiabkw) to describe anatomic position, type of injury and surgical procedure are as follows: Anatomic position: Mesh term: metatarsal bones, tarsal joints and tarsal bones, and tiabkw: tarsometatarsal, midfoot and lisfranc. We have found following terms for type of injury: Mesh term: dislocations, text word: fracture and title: injury. In the same way finally, for surgical interventions we have used following term: Mesh term: fracture fixation, fracture fixation, internal and arthrodesis and tiabkw: fixation and fusion. We also retrieved the references of the included studies for additional potentially eligible grey studies to measure outcomes. For retrieval of study paper similar strategy were applied in PubMed, Web of Science and Cochrane collaboration library. Duplicate study were checked and straight way excluded from total study database and from all these vast majority were excluded immediately based on title, and a fewer amount were excluded after review of the abstract.

Characteristics of study selection and data collection

4 studies with their follow up available in the current meta-analysis, involved total number(N) of 145

patients (146 feet) allotted respectively to ORIF (n = 73) and arthrodesis (n = 73) groups. Those all studies are high quality contained direct comparative study data of ORIF with arthrodesis included in this meta-analysis. Included all the studies have loss of follow up minority which result in the potential publication bias and estimated the source of decrease statistical power, and heterogeneity within variation of injury patterns due to study design error and treatment protocols. For current study, data were extracted on re-surgery for both either implant removal or complication, maintaining reduction quality (anatomical position) on the basis of postoperative follow up radiograph, and patient outcome score.

Of these two interventional group patients for re-surgery, we have kept all patients who went either to re-surgery for any complication and included all the studies explained reason and risk of return to the operating room. Reasons are implant failure, post traumatic complication, and loss of anatomic reduction. For outcome score this study unable to include all studies because some studies used rather than AOFAS score and we assessed standard mean difference for clinical outcome analysis. The key point of this study is anatomic alignment, without alignment none of the study supports; therefore we prioritize nonanatomic alignment on risk ratio. In the current meta-analysis there is high rate of implant removal though we have included 3 studies without protocols of implant removal, which increase the frequency of unwanted surgery.

Figure 1: Flow chart of study selection:

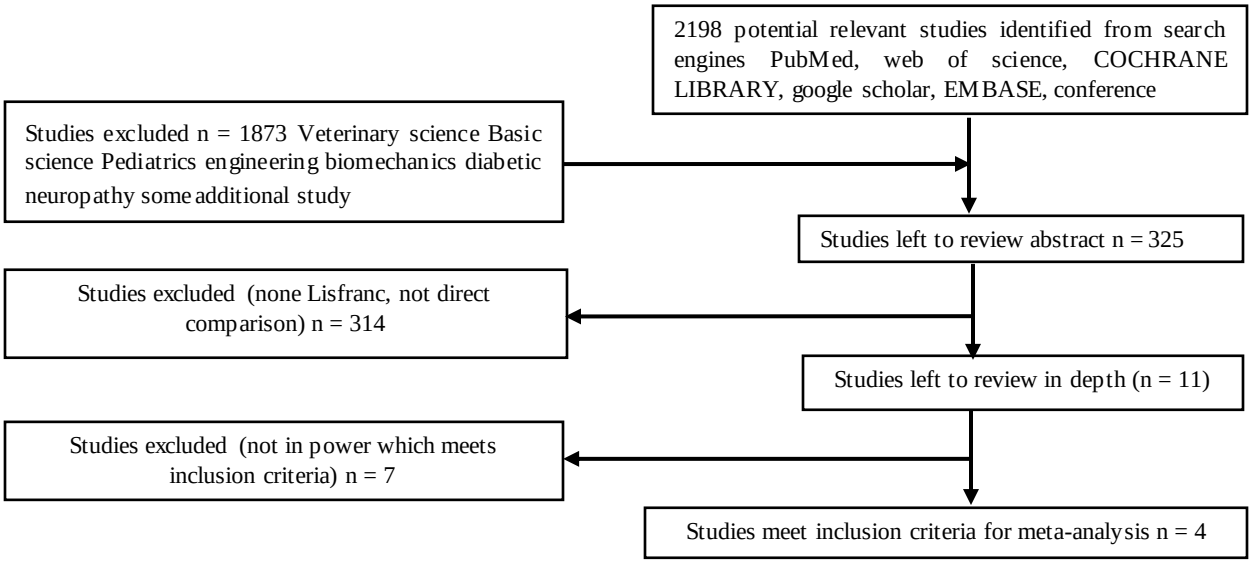


Table 1. Baseline information of included study.

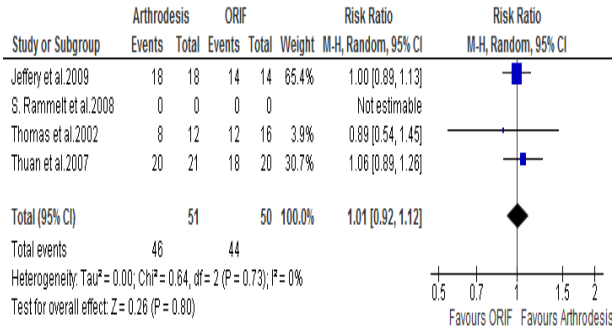
Included study and year	Study design	Sample size	interventions		Blinding	Method of outcome measured
			Arthrodesis	ORIF		
Jeffery et al. [17]	RCT	32	18	14	Double	SF-36, SMFA, radiography, secondary surgery
Rammelt et al. [19]	CCT	45	22	23	Open	AOFAS, Maryland foot score,
Thuan et al. [18]	PCS	41	21	20	Double	AOFAS, radiography, secondary surgery
Thomas et al. [16]	RCT	28	12	16	Single	BPFS, radiography, satisfaction

Note: PCS = prospective comparative study, **CCS** = Comparative cohort study. **RCT** = randomized control trial

Results

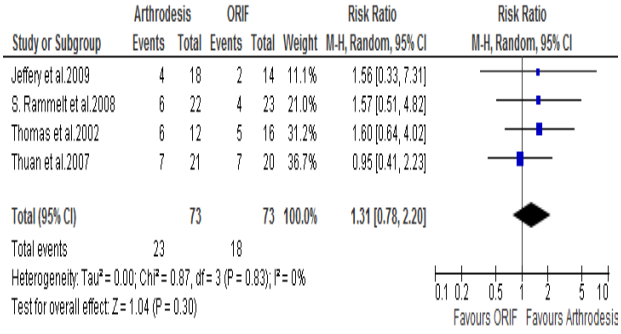
When anatomic alignment was taken in account as a key point, there was no use of surgery without maintaining. Here risk ratio was 1.01 [95% CI, 0.92, 1.12; Test for overall effect: Z = 0.26 (P = 0.80)]. Thomas et al advocated that there was low incidence of maintaining of anatomic reduction postoperatively on both procedures, which brings a failure bias Positive in this study.

Figure 2: The forest plot for the achievement of anatomic alignment between Arthrodesis and ORIF in the treatment of Lisfranc joint injury



There were slight high rates of postoperative complication on the arthrodesis group, the risk ratio was found 1.31 [95% CI, 0.78, 2.20; Test for overall effect: Z = 1.04 (P = 0.30)] indicating favoring ORIF slightly.

Figure 3: The forest plot for the risk ratio for postoperative complication between Arthrodesis and ORIF in the treatment of Lisfranc joint injury. ORIF groups are more vulnerable to complication.



When excluding the rate of hardware removal, the risk ratio was 0.39 [95% CI, 0.12, 1.26; Test for overall effect: Z = 1.58 (P = 0.11)], which does not support on the favor of ORIF.

After all considering the rate of patient undergoing hardware removal, the risk ratio was calculated to be 0.14 [95% CI, 0.04, 0.50 Test for overall effect: Z = 3.05 (P = 0.002)], which indicates very high incidence rate for implant removal on ORIF group, which directly affects the livelihood desire of the patient.

Figure 4: The forest plot for the risk ratio for re surgery after postoperative complication between Arthrodesis and ORIF in the treatment of Lisfranc joint injury.

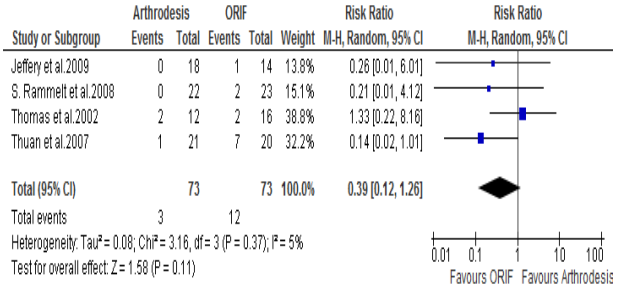
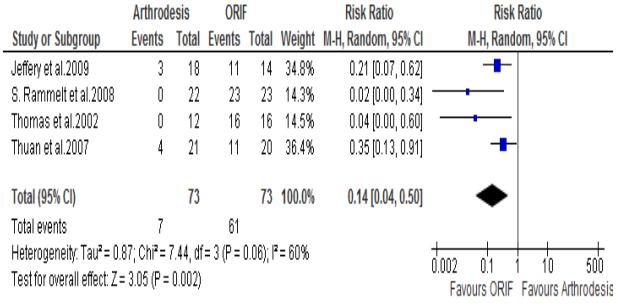


Figure 5: The forest plot for the risk ratio for implant removal to complete requirement of surgery between Arthrodesis and ORIF in the treatment of Lisfranc joint injury.



None of the following interventions supports strongly, here standard mean difference was calculated as 0.54 [95% CI, -1.97, 3.05 Test for overall effect: Z = 0.42 (P = 0.67)]. Since sample size was very small and the outcome score is different, Jeffery et al. advocated on SF-36, SMFA, and radiography score as well Thomas et al calculated BPFS, radiography, and satisfaction.

Figure 6: The forest plot for the std. mean difference of clinical outcome between Arthrodesis and ORIF in the treatment of Lisfranc joint injury.

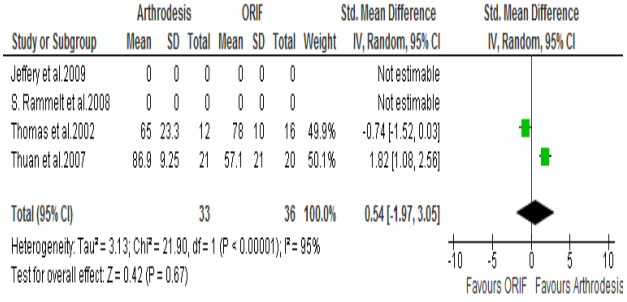


Table 2: Baseline information and outcome score

Included study and year	Study design	Number of study	Surgical intervention	Mean outcome score	Outcome measure	Mean duration of follow up
Yu et al. [13]	Case series	80	ORIF	88.4	AOFAS	24 months
Ghate et al. [22]	Case series	19	ORIF	77.5	AOFAS	30 months
Oliver et al. [23]	Case series	32	ORIF	91.7	AOFAS	14 years
Rajapakse et al. [24]	Case series	16	ORIF	78.3	AOFAS	42.6 months
Zwipp et al. [25]	Case series	22	Arthrodesis	76.8	Maryland	13 months
Reinhardt et al. [26]	Case series	25	Arthrodesis	81	AOFAS	42 months
Lin et al. [27]	Case series	16	Arthrodesis	70	AOFAS	36 months

Table 3: Comparison of AOFAS outcome score

intervention	No. of study	Number of study	Mean AOFAS Score	significance
ORIF	6	147	79.06	NA
Arthrodesis	4	84	77.425	NA

Discussion

Due to low frequency of lisfranc complex injury, minimum chance of misdiagnosis, which results devastating and chronic disabilities. None advocated on the support of close reduction, it was advised by several author expeditious diagnosis and accurate anatomic reductions were essence of need to maximize acceptable outcome. Traditionally the way of interventional treatment was ORIF but since a decade several authors advocated that arthrodesis was alternative to the lisfranc injuries [11, 26, 28-32].

Lisfranc injury, a vague term explains broad range of pathology either it could be purely ligamentous or compound fracture dislocation or comminuted or it could be all. Controversies arise on achievement of best interventional clinical outcome. Through this meta-analysis, some evidence was collected on the purpose of advantage of surgical intervention. We took into account 2 RCT, 1 PCT and 1 CCT comparison studies in a topic for systematic reviews and meta-analysis to resolve the issue. None of the included studies reported death of patient or any serious complication such as amputation. All of the 4 included studies had slightly different inclusion criteria but all studies followed gold standard surgical intervention including site of incision and implant fixation [7, 33, 34]. Although there was variation in statistical outcome from study to study, which increases certain amount of bias. On the basis of current meta-analysis all the studies of the ORIF group implant removal was not kept as gold standard protocol. But Jeffery had protocol to remove implant in ORIF group within certain weeks, which was decided by postoperative follow up radiograph. Obviously it brings a protocol bias to increase the outcome of high rates of implant removal in ORIF group, which strongly influenced the removal rates. Unfortunately another 2 groups had same rates of implant removal on ORIF group. Uneventfully there was increased risk of implant removal in the arthrodesis group due to complication on the group of Jeffery et al. [17] and Thuan et al. [18] with 95% CI respectively 0.21 [0.07, 0.62] and 0.35 [0.13, 0.91]. Moreover 3 patients of ORIF group in the Jeffery study had refused for implant removal stated that asymptomatic and they were satisfied with clinical outcome and livelihood life expectancy.

In the pooled results of anatomical alignment, all the studies had more or less equivalent results and show anatomical alignment was most important factor for determining clinical outcomes. This study couldn't demonstrate whether arthrodesis was superior or ORIF. Some author advocated that situation worse on the ORIF group in the condition of complete Lisfranc ligamentous injury while arthrodesis maintains anatomical alignment [17, 30]. It was also advised that high resolution radiological intervention was needed for further study to differentiate which of the following procedures had better postoperative outcome. Most importantly treatment of complete ligamentous injury tends to interventional challenge for most of the surgeons. Jeffery et al. [17] and Thuan et al. [18] advocated that reoperation rate in ORIF group somewhat much higher (75% to 79%) compared to arthrodesis group (17% to 20%). This supports for ligamentous injury arthrodesis favors to minimize the potential for significant long term expectancy of disability.

Other subgroup analysis for postoperative complication and re-surgery for postoperative complication also have unaltered conclusion for each of two surgeries. Most common complications among arthrodesis and ORIF are implant breakage and implant failure, while other complications are postoperative infection and hematoma formation. Hu

SJ et al[35] advocated dorsal plate fixation in the Lisfranc injury was much stable, low rate of implant failure and better clinical outcome than that of screw. Comparatively there was low incidence of nonunion and implant failure addressed in arthrodesis. Thus it was clearly supported by the patient on the basis of reduction of surgical pain and its complication choice of intervention supported towards arthrodesis. In this study we pooled some case series study to compare mean AOFAS score of two different study [13, 18, 19, 22-24, 26, 27, 35]. Here we had calculated mean AOFAS score of ORIF group and arthrodesis group independently. Total number of patient in ORIF group was 147 with mean AOFAS score 79.06 while in the arthrodesis group number of study 63 with AOFAS score 77.425. Comparatively less number of studies in the arthrodesis group, this study found slight higher AOFAS score in the group of ORIF. This current analysis also suggested that upcoming study should also pay attention to mention AOFAS score with its standard deviation for further study purpose.

Limitations of This Study

This meta-analysis has numerous limitations. First, this meta-analysis enclosed with confined studies, which had small sample sizes and incomplete data, which potentially affected the accuracy of the analysis. Second, we used AOFAS scale to determine outcome score, which was unavailable in the all articles also if available standard deviation (SD) was not calculated so there were error while performing statistical analysis. Third, significant heterogeneity was observed in the overall analysis, which might result in the pooled results being less convincing, although we applied random-effect models and conducted the subgroup analysis accordingly. Fourth, reporting bias could be introduced because positive results are more likely to be published. Only articles published in English were included, which might lead to publication bias.

Conclusions

Based on the currently available statistical analysis, it was justice on the favor of arthrodesis for Lisfranc injuries in terms of anatomical alignment, implant removal and outcome score. As we were discussed above ORIF had got persistent rate of implant removal, which can progressively increase the risk of re-surgery associated with livelihood desire of the patients. For the purpose of complete Lisfranc ligamentous injury arthrodesis has high success rate of maintaining anatomic alignment while after removal of implant worsens the condition of the patient in the ORIF group.

Authors Contributions

Perceived and designed the study; SS. Analyzed the data: SS, ZM, YT. Wrote the paper; SS. Searched the data, contributed to the discussion, and wrote, reviewed, and revised the manuscript; SS. Searched the data and reviewed and revised the manuscript: ZM, YT. Contributed to the discussion; HR. Helped with manuscript composition; YT. Topic selected, Initiated the idea and directed the entire strategy; YGR.

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