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Original Research Article

Functional Outcome of Lisfranc Injuries and its Clinical & Radiological Predictors: A Prospective, Hospital Based, Observational Study

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Abstract:

Background and Objectives: A condition characterized by the misalignment of one or more metatarsals in relation to the tarsus is commonly known as a "Lisfranc injury." In order to provide appropriate treatment and mitigate potential long-term repercussions, it is imperative to promptly and accurately diagnose these injuries. The primary objective of this study was to assess the clinical and radiological factors that influence the functional outcomes of different fixation techniques for treating Lisfranc fracture dislocations, as measured by the American Orthopaedic Foot and Ankle Society (AOFAS) score.

Material and Methods: The research was carried out as a prospective observational study at the Department of Orthopaedics, Government Medical College and Hospital in southern India. A total of 27 patients, aged between 18 and 70 years, who had undergone surgical fixation for lisfranc injury, were included in this study. The patients were followed up both clinically and by the use of follow-up x-rays. Prior to the study, approval was obtained from the institutional ethics committee, and all participants provided informed written consent.

Outcome measures: The assessment of functional outcome was conducted on the AOFAS midfoot scale. The radiological assessment was conducted by evaluating many factors, including the extent of reduction, diastasis, and adherence to the Myerson criteria, using follow-up X-ray examinations.

Results: The majority of patients, namely 19 individuals (70.3%), presented with a closed Lisfranc injury, whereas just 8 patients (29.6%) exhibited an open Lisfranc injury. Among the cohort of 27 patients, a total of 2 individuals received conservative treatment. Out of the 25 Lisfranc injuries that underwent surgical treatment, 14 patients (51.8%) experienced open reduction and internal fixation (ORIF) using K-wires. Additionally, 10 patients (37%) underwent fixation with screws, while 1 patient (4%) received dorsal plate fixation. Seventeen patients (68%) had satisfactory anatomical reduction, and this outcome was shown to be significantly correlated with improved functional outcome scores ($p=0.004$). The study observed that the functional outcome, as assessed by AOFAS mid-foot score, demonstrated outstanding results (95-100) in 5 instances (18.5%), good results (75-94) in 17 cases (63%), and fair results (50-74) in 5 cases (18.5%). No significant associations were seen between the cause of injury, related injuries, gender of the patient, and Myerson classification groups and the AOFAS midfoot score ($p>0.05$). Patients with closed Lisfranc injuries exhibited statistically significant improvements in AOFAS scores compared to those with open Lisfranc injuries ($p=0.024$). A statistically significant correlation was seen between the various treatment methods (K-wire, Screws, Plate, Conservative) & the AOFAS scores ($p=0.042$). The study observed that patients with diastasis less than 2mm & post-operative tarso-metatarsal sag less than 15 degrees on lateral view had superior functional results, as shown by the AOFAS score ($p=0.036$ and 0.007, respectively). Screw fixation demonstrates superior efficacy in producing a diastasis of less than 2mm when compared with K-wire and plate fixation, as indicated by a statistically significant p-value of 0.032.

Conclusion: The current study demonstrates that screw fixation for achieving stable anatomical reduction is more effective than K-wire and plate fixation in restoring medial cuneiform-2nd metatarsal diastasis to less than 2mm and tarso-metatarsal sagittal angle to less than 15 degrees. These radiological outcomes are crucial in the treatment of Lisfranc injury. Patients who have restoration of both radiological and functional criteria have favorable outcomes, including improved AOFAS mid-foot scores and reduced likelihood of experiencing postoperative pain and arthritis. Additional biomechanical investigations and clinical trials, encompassing a sufficient number of participants, are necessary in order to assess the efficacy and reliability of screws as a therapy modality for Lisfranc injuries.

Keywords: AOFAS score; Functional Outcome; Lisfranc Injuries; Radiological Predictors.

Introduction

The osseous tarsal complex consists of the navicular, cuboids, and three cuneiform bones. The support for the transverse arch of the foot is provided by the base of the second metatarsal. [1] The ligamentous support comprises robust ligaments that establish connections between the bases of the 2nd to 5th metatarsals. The Lisfranc ligament, which serves as a crucial connection between the medial cuneiform and the base of the 2nd metatarsal, has paramount importance in foot anatomy. [1,2] Patients exhibit a range of foot deformities, pain, edema, & soreness on the dorsal aspect of the foot.

The presence of plantar ecchymosis is considered to be a characteristic sign of a Lisfranc injury. The monitoring of compartment pressure is essential in order to exclude the presence of compartment syndrome in the foot. [2] Surgical intervention should be contemplated when there is a displacement of the tarsometatarsal joint measuring 2 mm from its anatomically correct location. [3,4] Optimal results can potentially be attained by employing anatomic reduction and stable fixing techniques. [4] Correction of the fracture-dislocation at the base of the 2nd metatarsal is crucial for achieving reduction. [3] The utmost importance lies in the precision and maintenance of reduction. Following the completion of reduction, it is recommended to utilize screw fixation for the medial column. When the medial column decreases in size along with the lateral metatarsals, the appropriate method of fixation is Kirschner (K) wire fixation [3]. There has also been a suggestion to employ primary arthrodesis as a treatment approach for Lisfranc injury. [5] Dorsal and/or medial plating may be utilized as a means of fixation in order to mitigate any damage to the joint surfaces. Based on empirical research, it has been found that the strength of fixation is similar to that of trans articular screws [6].

Furthermore, it has been seen that achieving anatomical reduction by therapeutic means can lead to excellent clinical outcomes. It is important to take into account the potential use of temporary external fixation or k-wire fixation [5,7] subsequent to closure reduction in cases of high-energy injuries accompanied by significant soft-tissue damage, until the soft tissues are suitable for final fixing. The potential consequences of Lisfranc injuries that are not treated or recognized in a timely manner can be significant, including conditions such as post-traumatic osteoarthritis and foot deformities like pes cavus. [8,9] Optimal results are achieved by timely and precise diagnosis, expeditious anatomical realignment, and the implementation of stable internal fixation. [4,6]

Only a few studies with limited sample sizes have studied the functional [10,11] effects of transarticular screws, k wire fixation, and dorsal bridge plating for Lisfranc injuries to dates. This prospective observational research's primary focus was to examine the efficiency of various fixation procedures for Lisfranc fracture dislocations utilizing the AOFAS score.

Aim and Objectives:

Primary Objective:

To evaluate the functional outcome of different forms of Lisfranc injury of foot using AOFAS (American Orthopaedic Foot and Ankle Society) scores in patients visiting OPD of Dept. of Orthopaedics in a Government Medical College and hospital of southern India.

Secondary Objectives:

- To examine the relationship between the severity of soft tissue injuries and the corresponding American Orthopaedic Foot & Ankle Society (AOFAS) score.
- To examine the impact of radiological predictors on X-rays and CT scans on the results, as determined by the AOFAS criteria.

Material and Methods:

The present study was conducted as a prospective observational study in a hospital setting. A total of 27 patients with Lisfranc injuries were included in the study, and they were attended to in the orthopedic outpatient department at the Department of Orthopaedics, Government Medical College and Hospital in South India. The research study obtained approval from the Ethical Committee, and all participating patients provided complete informed written permission.

Inclusion criteria: Patients who have reached skeletal maturity and have had a Lisfranc fracture.

Exclusion criteria:

- Additional fractures within the same limb
- Preexisting injuries in the same region of the foot
- Instances when patients have withheld consent.

Sample size calculation:

The formula provided n=4(SD)2/d2 represents the calculation of sample size (n) in terms of standard deviation (SD) and precision (D).

The standard deviation, as reported in a prior research with similar characteristics, was found to be 9.5. Additionally, a precision value of 3 was chosen. Therefore, the sample size (n) was calculated using the formula n = (4 * 9.5 * 9.5) / (3 * 3), resulting in a sample size of 40. However, as a result of the COVID-19 pandemic and subsequent lockdown measures, the number of patients seeking treatment at the Outpatient Department (OPD) or Casualty was significantly restricted. Consequently, the researchers were compelled to conduct the study utilizing the limited pool of accessible cases.

A total of 29 individuals diagnosed with Lisfranc injuries were included in the research, with 27 patients meeting the specified recruiting requirements. One participant was omitted from the study due to the presence of concomitant fractures in the tibia and fibula. One patient was not included in the subsequent monitoring or assessment.

Method of data collection:

The study recruited patients who had Lisfranc injuries and sought treatment in the emergency department or an outpatient department, based on specific inclusion and exclusion criteria.

The researchers collected demographic data, clinical information, injury features, imaging data, and therapy details in a prospective manner. Subsequently, the patients were subjected to clinical monitoring and follow-up x-ray examinations.

Outcome measures:

The clinical assessment included inquiring about the existence and intensity of pain, if applicable, and documenting the findings.

The duration of bed rest, the number of days required to resume activities of daily life, and the overall duration of absence from work were documented. Various consequences were assessed, including infection at surgical site, post-traumatic arthritis, deformities, malunion, compartment syndrome, deep vein thrombosis (DVT), and nerve palsy. The assessment of functional outcome was conducted on the AOFAS midfoot scale.

According to the AOFAS midfoot score, which is recognized as a reliable measure, ratings ranging from 90 to 100 points are classified as "excellent," ratings from 80 to 89 points are categorized as "good," ratings from 60 to 79 points are considered "fair," and ratings below 60 points are deemed "poor." The radiological assessment involved the use of many indicators, including the quality of reduction, diastasis, and Myerson criteria, to evaluate the result. This evaluation was conducted by the analysis of follow-up x-ray images.

Statistical Analysis:

The data was inputted into Microsoft Excel and subsequently analyzed with STATA version 14. The categorical variables were summarized in terms of proportions. The duration of follow-up was reported as the median value together with the interquartile range. The correlation among categorical variables was assessed using either the chi-square test or the Fisher's exact test. The concept of statistical significance was operationalized as a threshold of a P value equal to or less than 0.05.

Results:

Among the sample of 27 patients, it was observed that 13 individuals, representing 48% of the total, fell within the age range of 30 to 50 years. Furthermore, a significant majority of the patients, namely 85%, were identified as males.

The table below presents additional demographic factors, including manner of injury, concomitant injuries, kind of Lisfranc injury, therapy administered, and the degree of reduction following surgical fixation. (Table 1)

Table 1: Demographic variables

Variables		N	%
Age groups	<30 years	08	30
	30-50 years	13	48
	>50 years	06	22
Gender	Male	23	85
	Female	04	15
Mode of injury	Road traffic accidents	15	55.5
	Fall from height	08	29.6
	After slip and fall	03	11.1
	Direct trauma	01	3.7
Associated Injuries	Nil	19	70.3
	Metatarsal fractures	05	18.5

	Upper limb fractures	03	11.1
Type of Lisfranc injury	Closed	19	70.3
	Open	08	29.6
Treatment done	K-wire	14	51.8
	Screw	10	37
	Dorsal plate	01	3.7
	Conservative	02	7.4
Quality of reduction after surgical fixation	Anatomic	10	40
	Near anatomic	07	28
	Non-anatomic	08	32

Based on the Myerson categorization, it was seen that 7 individuals (25.9%) fell under category A1, 9 individuals (33.3%) fell under category B1, 6 individuals (22.2%) fell under category B2, and 5 individuals (18.5%) fell under category C1. This research did not include any individuals who presented with Lisfranc injuries of Myerson A2 and C2 types. The cases were categorized into two groups based on the measurement of the distance between the medial cuneiform and the base of the second metatarsal on anteroposterior and lateral views in post-operative X-rays. One group consisted of individuals with diastasis measuring ≤2mm (n=16, 64%) and a tarso-metatarsal sag measuring <15 degrees (n=18, 72%). The other group consisted of individuals with diastasis measuring >2mm (n=9, 36%) and a tarso-metatarsal sag measuring >15 degrees (n=7, 28%).

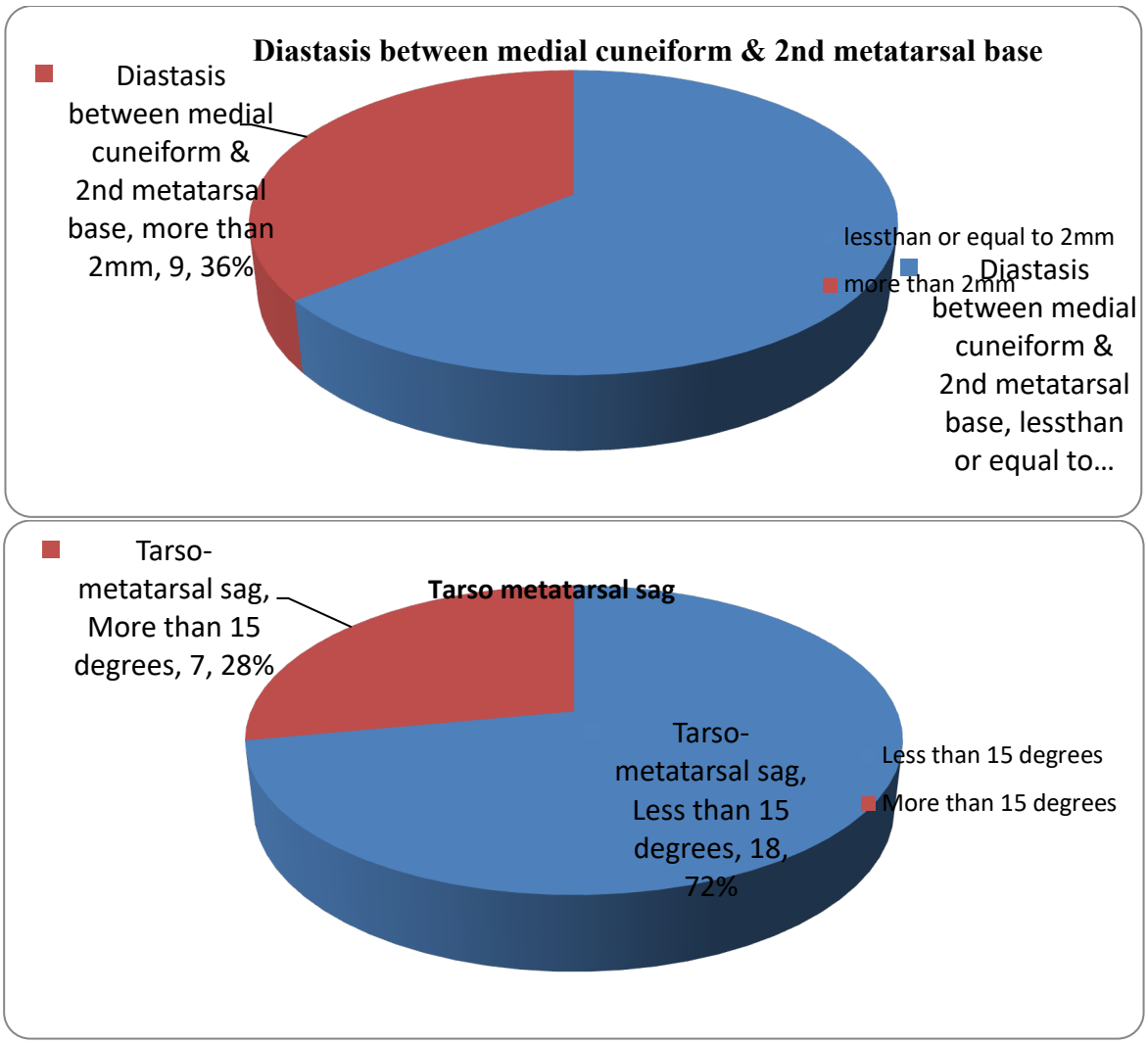

Figure 1: (a) and (b): Distribution of patients on the basis of post-operative reduction criteria on post-operative radiographs

The investigation of the relationship between several treatment methods (conservative, K-wire, Screw, Plate) and the ability to resume work or engage in sports activities did not provide any statistically significant findings (p=0.467).

Table 2: Association between type of treatment option obtained and days spent away from work/sports (n=27)

Patient Group	Duration till return to work / sports				P value
	0-40 day (n=1)	41-80 days (n=18)	81-120 days (n=6)	>120 days (n=2)	
Conservative(n=2)	0 (0%)	1 (50%)	1 (50%)	0 (0%)	**0.467 (NS)**
K-wire(n=14)	0 (0)	9 (64.3%)	3 (21.4%)	2 (14.3%)	
Screw (n=10)	1 (10%)	8 (80%)	1 (10%)	0 (0%)	
Plate (n=1)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	
Total	1 (3.7%)	18 (66.7%)	6 (22.2%)	2 (7.4%)	

NS- Not Significant.

The study observed the functional outcome of mid-foot injuries using the American Orthopaedic Foot and Ankle Society (AOFAS) mid-foot score. The results indicated that 18.5% of cases achieved an outstanding score (95-100), 63% achieved a good score (75-94), 18.5% achieved a fair score (50-74), and 2.5% achieve a poor score (<50).

Table 3: Association of AOFAS score with different parameters

Association of AOFAS score with		P value
1.	Gender	0.250 **(NS)**
2.	Mode of injury	0.836 **(NS)**
3.	Associated injuries	0.786 **(NS)**
4.	Limb side affected	0.767 **(NS)**
5.	Planter ecchymosis	0.767 **(NS)**
6.	Fleck sign	0.810 **(NS)**
7.	Myerson classification types	0.163 **(NS)**

NS- Not Significant

Patients suffering open Lisfranc injuries exhibited significantly lower AOFAS scores in comparison to those with closed Lisfranc injuries (p=0.024).

A statistically significant correlation has been shown between several treatment methods, including K-wire, screws, plate, and conservative approaches, and AOFAS scores. Significant outcomes were achieved with the utilisation of screw fixation, as shown by a statistically significant p-value of 0.042. Screw fixation demonstrates superior efficacy in producing a diastasis of less than 2mm when compared to both K-wire and plate fixation, as indicated by statistical analysis with a p-value of 0.032. Those who achieved anatomical or near anatomical reduction had superior functional outcome scores in comparison to those who did not achieve anatomical reduction (p=0.004). Patients who had a diastasis measuring less than 2mm and a post-operative tarso-metatarsal sag measuring less than 15 degrees on a lateral view had superior functional outcomes, as assessed by the American Orthopaedic Foot and Ankle Society (AOFAS) score, in comparison to patients who had a diastasis measuring greater than 2mm and a tarso-metatarsal sag measuring greater than 15 degrees (p=0.036 and 0.007, respectively). A statistically significant correlation was found among soft tissue grading & AOFAS score within open Lisfranc injuries (p=0.029), however in closed Lisfranc injuries, the association was not statistically significant (p=0.173).

Table 4: Association between different surgical procedure and quality of reduction

Surgical procedure	Quality of reduction				P value
	Anatomic	Near anatomic	Non-anatomic	Total	
K-wire	2(8)	5(20)	7(28)	14(56)	0.010 **(S)**
Screw	8(32)	1(4)	1(4)	10(40)	
Plate	0(0)	1(4)	0(0)	1(4)	
Total	10(40)	7(28)	8(32)	25(100)	

S- Significant.

One of the most often observed complications subsequent to a Lisfranc injury is the occurrence of persistent pain resulting from degenerative arthritis, as well as the development of postoperative surgical site infections. **(Table 5)**

Table 5: Association between post-operative complications and AOFAS score

Association of AOFAS score with		P value
1.	Postoperative infections	0.363 **(NS)**
2.	Chronic pain	0.007 **(S)**
3.	Deformity	0.014 **(S)**

NS- Not Significant, S- Significant. Figure 2 & 3 showing the preoperative radiological image sustained a Lisfranc injury and the postoperative image after surgical correction.

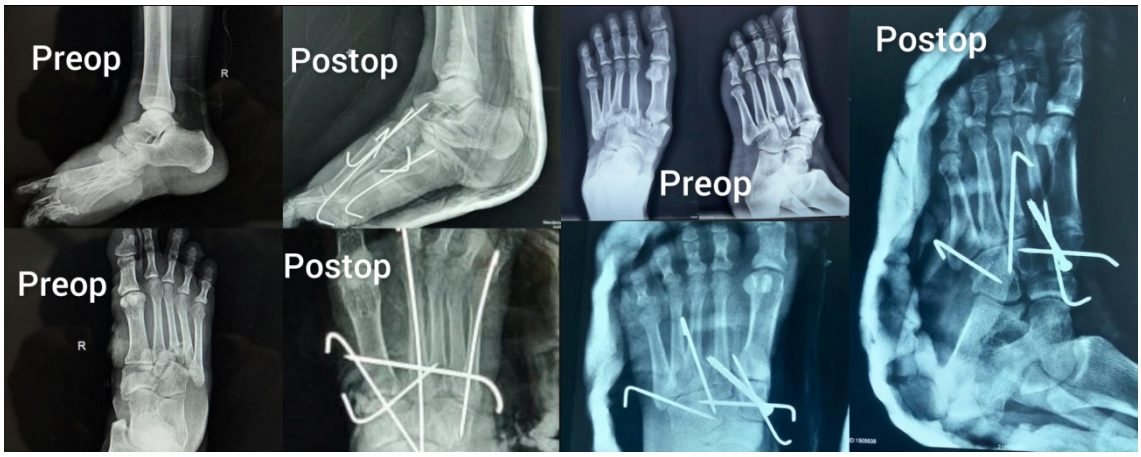

Figure 2 & 3: Radiological image (Preoperative & Postoperative)

Discussion:

The Lisfranc injury accounts for a mere 0.2% of all fractures or dislocations, with an annual incidence rate of 1 in 55,000 individuals. [1,2,12]. The management of various categories of Lisfranc injuries has seen a variety of phases, progressing from non-operative approaches to surgical interventions. Operative procedures have undergone significant advancements, transitioning from K-wire fixation to screw plate, and currently include suture button approaches. Through an enhanced comprehension of various ligamentous structures, as well as the use of diverse radiographic perspectives such as stress X-rays, even the most inconspicuous Lisfranc lesions may now be accurately recognized and effectively treated.

The operative treatment options for Lisfranc injuries often involve the use of screw or plate fixation in the medial and central columns of the foot. Conversely, the movable lateral column is typically addressed by the use of K-wires. In the current study, the predominant method of treatment for open Lisfranc injuries involves the use of K-wires.

A research done by Latoo IA et al [13] examined the treatment outcomes of 20 patients with Lisfranc injury who had K-wire fixation. The mean AOFAS score was found to be 78.36, indicating that patients experienced a reduction in points mostly due to discomfort and limitations in recreational activities. The percentage of reduced loss is lower in individuals who were immobilized for an extended duration. Only three studies [14-16] utilized K-wires for definitive fixation following open reduction. In a research done by Alberta et al. [17], comparable outcomes were seen when comparing the use of screw and plate fixation methods. In a separate investigation carried out by Lau et al. [6], precisely a case series, no significant disparity in the long-term functional result was seen when comparing the use of screw, plate, or combination therapy in terms of AOFAS and FFI scores. However, a separate research done by N. Kirzner et al. [18] found that dorsal bridge plate fixation yielded superior functional result ratings compared to screw and combo therapy.

The demographic parameters of the current study were found to be congruent with those of a prior study done by Stodle AH et al. [19], despite the relatively small sample size.

Achieving a decrease of less than 2mm in the diastasis between the medial cuneiform and the 2nd metatarsal, as well as maintaining a tarso metatarsal sag of less than 15 degrees, is crucial in order to restore the anatomy and get favorable functional result ratings. In the present study, a total of 10 patients (40%) had anatomical reduction, 7 patients (28%) received near-anatomical reduction, and 8 patients (32%) were subjected to non-anatomical reduction. Patients who have anatomical reduction demonstrate a notable enhancement in AOFAS midfoot outcome ratings compared to those who get near and non-anatomical reduction. The present

findings are similar with prior investigations conducted by Thomson MC et al. [20] and Richter M et al. [21].

In our study, there is statistically significant association between types of treatment (K-wire, Screws, Plate, and Conservative) and AOFAS scores. Excellent results were obtained with screw fixation. These findings were not in consistent with findings of previous similar studies done by Alberta et al [17] and Simon Lau et al [6] where their studies shows similar outcome scores for both screw and plate fixation. According to study conducted by N. Kirzner et al [18] plate is having better functional outcome than screws. As there is only one case of plate fixation in our study, its statistical significance cannot be implied and more sample size and further studies are needed.

Our investigation revealed a notable correlation between soft tissue grading and AOFAS score in open Lisfranc injuries. However, no significant correlation was seen amongst soft tissue grading in closed Lisfranc injuries and AOFAS mid-foot scores. There exists a single research throughout the literature that examines the Tscherne soft tissue grading and Lisfranc injuries, which was carried out by Ismail Demirkale et al [22]. The present study aligns with the results obtained in our investigation pertaining to open fractures, but not with regards to closed Lisfranc injuries.

The study revealed that the prevailing consequences observed subsequent to Lisfranc injury mostly encompass persistent pain resulting from degenerative arthritis and surgical site infection following the operation. Numerous authors have reached the consensus that the occurrence of degenerative alterations is significantly heightened in cases where the existence or magnitude of an injury has been initially overlooked, inadequately addressed, or if the anatomical integrity has not been fully restored. This holds true even in instances where the injury is solely ligamentous and lacks osseo-ligamentous involvement. In our research, we found no statistically significant correlation between surgical site infection and AOFAS result scores. However, we did see a substantial link between patients experiencing persistent pain and deformity, and their AOFAS outcome ratings. The results of this investigation were congruent with the findings reported by Stavlas et al. [23]

Limitations of the study:

The initial sample size for this study was 40. However, as a result of the COVID-19 pandemic and subsequent lockdown measures, there was a decrease in the number of patients seeking medical attention at the Outpatient Department (OPD). Consequently, the researchers were compelled to conduct their study with a limited sample size of 27 cases. In addition to this, the patients under investigation received treatment from several surgeons who possessed differing levels of experience, despite all patients being treated inside the confines of the same facility. The plan of management was determined by the attending surgeon who looked after the patients, perhaps influencing the eventual result.

Conclusion:

The current study demonstrates that screw fixation, when used for stable anatomical reduction, outperforms K-wire and plate fixation in achieving the desired outcomes of reducing medial cuneiform-2nd metatarsal diastasis to less than 2mm and tarso-metatarsal sag to less than 15 degrees. These radiological goals are crucial in the treatment of Lisfranc injury. Patients who have restoration of both radiological and functional criteria have favorable outcomes, including improved AOFAS mid-foot scores and reduced likelihood of experiencing postoperative pain and arthritis. Additional research in the field of biomechanics and clinical trials, encompassing a sufficient number of participants, is necessary in order to assess the efficacy of screws as a treatment option for Lisfranc injuries.

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