ORIGINAL ARTICLE

Comparison of two surgical techniques for Lisfranc injuries; closed reduction and fixation versus primary partial arthrodesis

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ABSTRACT

BACKGROUND: This study reviewed the outcomes of Lisfranc injuries treated by primary partial arthrodesis (PPA) or closed reduction and internal fixation (CRIF).

METHODS: A retrospective review was made of patients who underwent PPA or CRIF for a Lisfranc injury after low-energy trauma, and follow-up was assessed according to radiographic, and clinical outcomes. A total of 45 patients with a median age of 38 years were followed up for an average of 47 months.

RESULTS: The average American orthopaedic foot and ankle society (AOFAS) score was 83.6 points in the PPA group and 86.2 points in CRIF group ($p>0.05$). The mean pain score was 32.9 in the PPA group, 33.7 in the CRIF group ($p>0.05$). Secondary surgery for symptomatic hardware was required in 78% of the CRIF group and in 42% of the PPA group ($p<0.05$).

CONCLUSION: Treatment of low-energy Lisfranc injuries with either PPA or closed reduction and fixation produced good clinical and radiological outcomes. The total AOFAS scores were comparable between two groups. However, the function and pain scores were seen to improve more with closed reduction and fixation while there was a greater requirement for secondary surgery in the CRIF group.

Keywords: Closed reduction; lisfranc injuries; midfoot; primary partial arthrodesis.

INTRODUCTION

A disruption of the osseoligamentous complex of the tarsometatarsal (TMT) joint is defined as a Lisfranc injury. The Lisfranc ligament is the strongest ligament of the foot, which extends from the lateral aspect of the medial cuneiform to the medial aspect of the second metatarsal base. Lisfranc ligament injuries result in disruption of the foot's transverse arch, leading to pain and residual deformity of the foot.[1]

The scale of a Lisfranc injury varies from low-energy sports injuries to high-energy crush injuries. The mechanism of the injury is axial loading of the hyper-plantarflexed foot. These traumas vary from pure ligamentous injuries to severely comminuted TMT fracture-dislocation. The restoration of the TMT anatomy and maintenance of normal tarsal congruity is the mainstay of the treatment to reduce the risk of arthritis and achieve good results.[2] There is a wide spectrum of treatment methods, ranging from conservative treatment with a plaster cast, percutaneous K-wire, open reduction, and internal fixation with a trans-articular screw or a dorsal bridging plate or primary arthrodesis. The main aim of the treatment is the anatomic reduction of the TMT joint. Good clinical results are correlated with anatomic reduction of the TMT joint.[3]

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Open reduction and internal fixation (ORIF) is a well-established technique in the treatment of Lisfranc injuries. However, extended soft-tissue dissection and the association of this technique with a high risk of complications due to dissection led to advancements in percutaneous techniques for the treatment of Lisfranc injuries.[4] Historically, partial arthrodesis has been suggested as a salvage procedure after failed conservative or surgical treatment of Lisfranc injury. In recent years, primary partial arthrodesis (PPA) has been used in acute Lisfranc injuries and good outcomes have been observed.[5]

The purpose of this study was to compare the clinical and radiological outcomes of patients treated with PPA or closed reduction and internal fixation (CLIF) for an acute Lisfranc injury.

MATERIALS AND METHODS

Approval for this study was granted by the Hospital Internal Ethics Committee. A retrospective analysis was made of the orthopedic operative records to identify patients who underwent surgery for acute Lisfranc injury between 2013 and 2019. The patients included in the study were those aged 18–60 years with a Lisfranc injury classified as Myerson Type B treated with PPA or CLIF, and a follow-up period of at least 12 months. The exclusion criteria were defined as involvement of third, fourth, or fifth metatarsals, concomitant fracture in the lower extremity, the presence of inflammatory arthritis, a Lisfranc injury other than Myerson Type B, and those treated with ORIF. After the application of the exclusion criteria, 45 patients were found to be eligible for the study. All patients were contacted by phone, e-mail, or message to participate in the study. Those who agreed to participate were invited to complete the American orthopaedic foot and ankle society score for the midfoot (AOFAS), and a record was made of the general medical history and physical examination findings. The AOFAS is based on a scale from 0 to 100, where 0 indicates the worst results and 100 the best results. There are also three subcategories of pain (0–40), function (0–45), and alignment (0–15).

The pre-operative X-ray and computed tomography (CT) scans were evaluated. The fractures were classified according to the Myerson et al.[6] classification. Patients in Group 1 were treated with fixation with PPA (arthrodesis of the first two TMT joints) and those in Group 2 with fixation with closed reduction and percutaneous internal fixation.

The alignment of Lisfranc reduction was evaluated on weight-bearing anteroposterior, lateral, and oblique radiographs, and the reduction was classified into three categories anatomic, nearly anatomic, and non-anatomic.[4] In the radiological examination, a normal result was defined as the medial edge of the second metatarsal parallel to the medial border of the second cuneiform on both the anteroposterior and oblique views of the foot. On the lateral X-ray, a metatarsal should not be located more dorsal than its corresponding tarsal bone. The space between the medial cuneiform and second metatarsal base should be <2 mm. The reduction was considered normal anatomic if the radiological relationships were maintained postoperatively, nearly anatomic if the reduction was within 2 mm, and non-anatomic if >2 mm, or there was >15 of persistent talo-first metatarsal angulation.

The surgical technique described by Henning et al.[7] was used in patients with PPA. A 5–6 cm dorsal longitudinal incision was made over the interval between the 1st and 2nd TMT joints. After removal of all the articular surface with an osteotome or a small curette, the TMT joint was reduced with a clamp and the reduction was secured with one or two screws for the first TMT joint and one screw from the medial cuneiform to the second metatarsal base. The final reduction and screw positioning were confirmed with fluoroscopy (Figs. 1a-d). In the closed reduction group, the TMT joint was reduced with a pointed reduction clamp between the medial aspect of the medial cuneiform and the dorsolateral aspect of the second metatarsal. After confirmation of the reduction with fluoroscopy, a 1–2 cm skin incision was made over the first metatarsal. The underlying soft tissue and deep fascia were incised carefully to prevent injury to the neurovascular bundle and extensor tendons. The first TMT joint was secured with one screw inserted from the first metatarsal to the medial cuneiform. Then, a second small incision was made over the medial aspect of the medial cuneiform. After confirmation of the reduction, a screw was inserted between the medial cuneiform and the second metatarsal base (Figs. 2a-f). All surgeries were carried out either directly by the

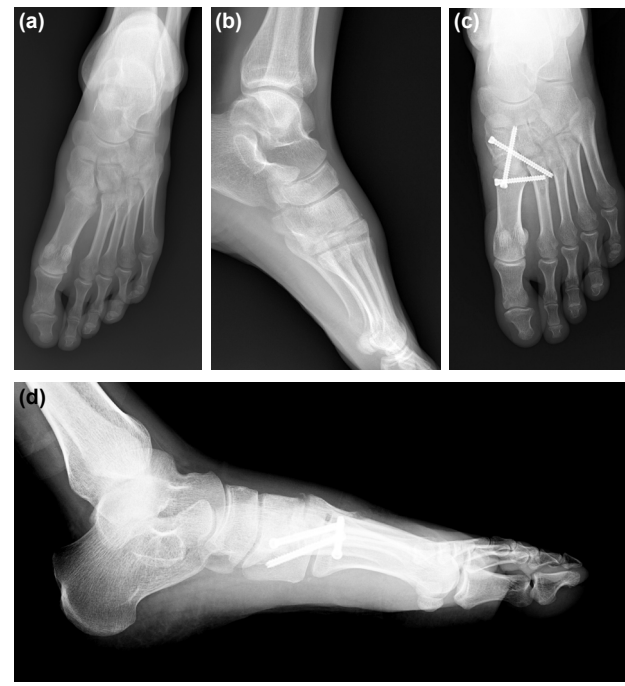

Figure 1. Case study with PPA, **(a and b)** pre-operative X-rays of the patient, **(c and d)** post-operative X-rays of the patient.

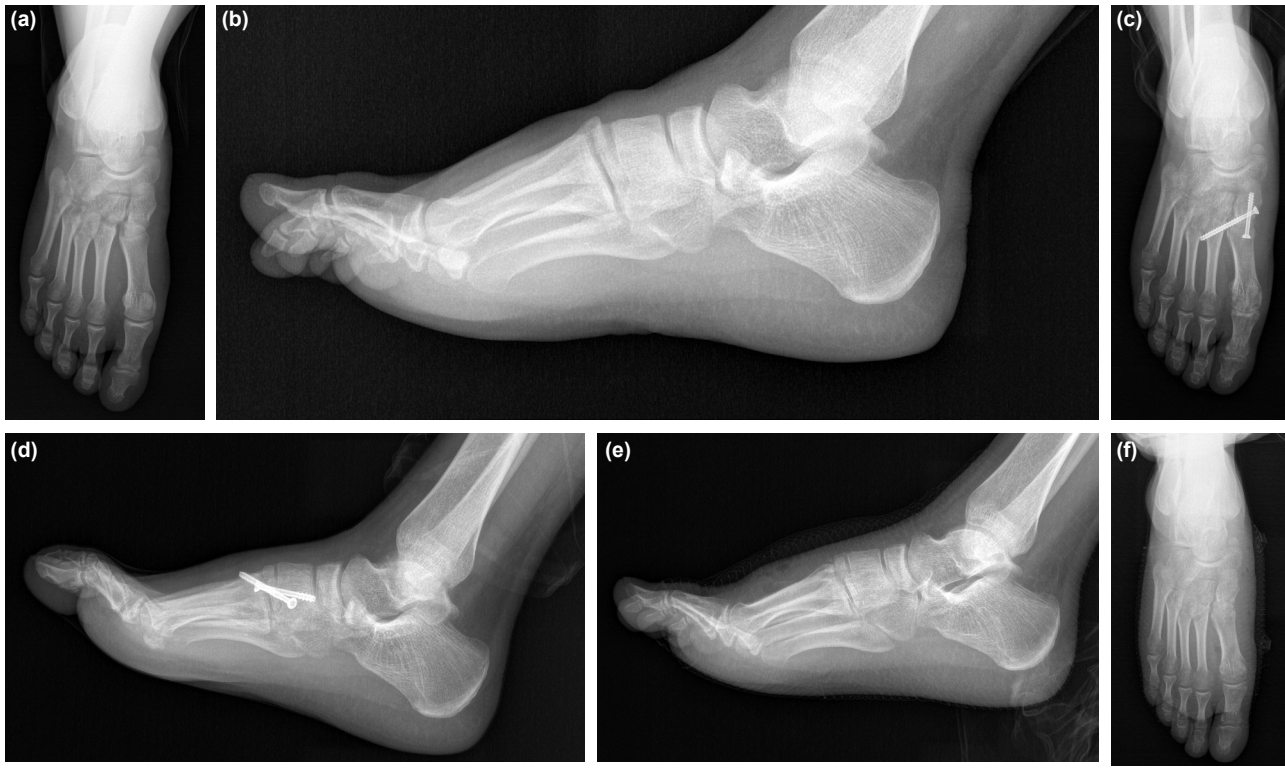

Figure 2. A case study with CRIF, **(a and b)** pre-operative X-rays of the patient, **(c and d)** post-operative X-rays of the patient, and **(e and f)** X-rays of the patient after hardware removal.

senior author or by another orthopedic surgeon under the direct supervision of the senior author. The CRIF technique was particularly performed in the patients with swelling and hematoma at the surgical site and in the professional athletes. If the closed reduction cannot be maintained intraoperatively, ORIF or arthrodesis were performed. The patients with ligamentous injury and those with mid-foot arthritic changes on the radiological examination were treated with PPA.

Post-operative follow-up consisted of examinations at 2, 4, and 8 weeks, 6 months, and 1 year. A plaster cast was applied to all patients for 2 weeks postoperatively. After 2 weeks, ankle motion exercises were started. Weight-bearing was restricted for 6–8 weeks in all patients. Gradual weight-bearing was allowed according to the clinical and radiological examination findings of no pain with palpation over the foot and normal radiological examination with no radiolucency around the screw, and no screw breakage. Removal of the screws was not routinely advised but any symptomatic implant was removed at the end of the 1st year postoperatively at the earliest.

Statistical Analysis

Data obtained in the study were analyzed statistically using SPSS version 22.0 software. Descriptive statistics were stated as mean, standard deviation, median, minimum, and maximum values, frequency, and percentage. The independent samples t-test and the Mann-Whitney U test were used for the comparison of quantitative data. The Chi-square test was applied in the comparisons of qualitative data. $P<0.05$ was accepted as statistically significant.

RESULTS

Demographic Results

An evaluation was made of 45 patients, comprising 34 (65.6%) males and 11 (24.4%) females, with a mean body mass index (BMI) of 22.16±2.04, and a mean post-operative follow-up period of 47.5±13.04 months (range, 20–70 months). The Lisfranc injury was treated with arthrodesis in 26 (57.7%) patients and with CRIF in 19 (42.2%) patients. When the subjects were separated into two groups according to the fixation technique of the Lisfranc injury, no statistically significant differences were determined between the two groups in respect of gender distribution, age, post-operative follow-up, and BMI of the patients (Table 1). All patients had Myerson Type B Lisfranc injury.

In the PPA group, the mechanism of injury was fall from <2 m in 22 patients and axial loading during a sporting activity in four patients. The mean time to surgery was 3 days (range, 1–8 days). The arthrodesis construct included two screws in 21 patients and three screws in five patients. Secondary surgery for hardware removal was applied to 11 (42%) patients. There were 2 (7.5%) patients with midfoot degeneration.

In the CRIF group, the mechanism of injury was fall from <2 m in 14 patients and axial loading during a sporting activity in

Table 1. Demographic data of the patients

	PPA	CRIF	p
Gender n (%)			
Female	6 (23.0)	5 (26.0)	>0.05
Male	20 (77.0)	14 (74.0)	>0.05
Age, mean±SD (min-max)	38.3±13.4 (23–70)	40.4±14.1 (24–66)	>0.05
BMI, mean±SD (min-max)	22.8±2.3 (17–29)	21.2±2.1 (20–27)	>0.05
Mean time to surgery (day)	3±1.6 (1–8)	2.3±1.3 (1–6)	>0.05
Post. Op., mean±SD (min-max)	49.3±11.2 (22–72)	45±15.1 (20 – 64)	>0.05
Screw for fixation (%)			
1 screw	0	5 (26.0)	
2 screw	21 (80.7)	14 (74.0)	
3 screw	5 (19.3)	0	
Hardware removal (%)	11 (42.0)	15 (78.0)	<0.023
Degeneration (%)	2 (7.5)	3 (15.7)	>0.05
Reduction (%)			>0.05
Non-anatomical	0	0	
Nearly-anatomical	5 (19.3)	4 (21.0)	
Anatomical	21 (80.7)	15 (79.0)	
Mechanism of injury (%)			>0.05
Fall (<2 m)	22 (85.0)	14 (74.0)	
Sport	4 (15.0)	5 (26.0)	

Post. Op.: Postoperative follow-up period; SD: Standard deviation; PPA: Primary partial arthrodesis; CRIF: Closed reduction and internal fixation.

Table 2. AOFAS for midfoot of the patients

	PPA	CRIF	p
	Mean±SD (min-max)	Mean±SD (min-max)	
Pain	32.9±6.5 (20–40)	33.7±5.6 (20–40)	>0.05
Function	37.7±5.6 (17–45)	39.2±7.8 (17–45)	>0.05
Alignment	13.0±4.7 (0–15)	13.0±3.1 (0–15)	>0.05
Total	83.6±10.8 (37–90)	85.9±17.4 (37–94)	>0.05

AOFAS: American Orthopaedic Foot and Ankle Society; SD: Standard deviation; PPA: Primary partial arthrodesis; CRIF: Closed reduction and internal fixation.

five patients. The mean time to surgery was 2.3 days (range, 1–6 days). The Lisfranc injury was fixed using one screw in five patients, and two screws in 14 patients. Hardware removal surgery was applied to 15 (78%) patients. There were 3 (15.7%) patients with midfoot degeneration.

There was a statistically significant difference between the two groups in respect of hardware removal. Secondary surgery for hardware removal was required by more patients in the CRIF group than in the PPA group. There were 2 (7.5%) patients with midfoot degeneration in the PPA group and 3 (15.7%) patients in the CRIF group with no statistically significant difference between the groups. The reduction quality was similar in both groups. There were no patients with non-anatomic reduction in either group. In 5 (19.3%) patients in the PPA group and 4 (21%) patients in the CRIF group nearly – anatomic reduction was obtained with a 2 mm gap between the second metatarsal head and medial cuneiform.

Clinical Results

In the evaluation of the outcomes after osteosynthesis of the Lisfranc injury, the mean AOFAS score was 83.6 in the PPA group and 85.9 in the CRIF group with no statistically significant difference. According to the subsections of the AOFAS questionnaire, the mean pain score was 32.9 in the PPA group and 33.7 in the CRIF group with no statistically significant difference. The mean function score was 37.7 in the PPA group and 39.2 in the CRIF group with no statistically significant difference. The mean alignment score was 13.0 in the PPA group and the CRIF group, with no statistically significant difference determined between the groups (Table 2).

DISCUSSION

In the present study, there was no statistical difference in the mean AOFAS scores between the patients treated with

CRIF and those treated with PPA. Although the CRIF group demonstrated higher scores in the subsections of the AOFAS questionnaire, there was no statistically significant difference between the two groups in terms of the mean pain, alignment, and function scores. In the literature, AOFAS midfoot scores have been reported to range between 67 and 84 in patients with a Lisfranc injury treated with ORIF and between 70 and 87 in patients treated with primary arthrodesis.[8,9] Comparable results were obtained in the present study, with a mean AOFAS score of 83.6 in patients treated with PPA and 86.2 in patients treated with CRIF. A previous meta-analysis reported metalwork removal was performed in 19% of patients treated with PA and in 73% of patients treated with ORIF.[3] Secondary surgery for the removal of symptomatic hardware was performed at the rate of 43% in the patients treated with PPA and at 78% in the patients treated with CRIF. Micromotion in the Lisfranc joint may cause symptoms related to metalwork.

Anatomic reduction and stable fixation has been correlated with superior outcomes, and accordingly, ORIF has been accepted as the gold standard treatment of Lisfranc injuries.[10,11] In a review conducted by Stavlas et al.,[12] it was suggested that ORIF with screws is a reliable method, especially for the fixation of the first three TMT. However, the anatomic reduction can also be achieved with closed reduction and fixed with percutaneous techniques until an obstacle leads to inadequate reduction, such as bony fragments or soft-tissue entrapment.[13] CLIF is a less invasive and simple technique compared to ORIF. In 2003, Perugia et al.[4] reported 42 patients with Lisfranc fracture-dislocation treated with CRIF and found no significant differences in outcome scores between patients with anatomic reduction and nearly anatomic reduction. Subsequently, Puna and Tomlinson. described the ideal indications for CRIF in the treatment of Lisfranc injury as bony avulsion and minor displacement to facilitate closed reduction without any bony fragment or soft-tissue entrapment, patients with compromised soft tissue envelope, and low-energy injuries in athletes.[14] In the present study, the patients with compromised soft tissue were treated with CLIF and there was no patient with non-anatomical reduction postoperatively. Achievement of anatomic reduction may not be feasible in patients with severe fracture-dislocation.

Historically, primary arthrodesis was reserved as a salvage procedure, but it has been suggested as an alternative method for acute Lisfranc injuries.[5] Ly and Coetzee[15] suggested the indications for primary arthrodesis as the following: Major ligamentous injury of TMT joints, a severely comminuted intra-articular fracture of the first and second metatarsal head, and crush injuries of the midfoot with TMT fracture-dislocation. Kirzner et al.[16] reported improved AOFAS scores in patients treated with primary arthrodesis compared to patients treated with ORIF. It was suggested that good results can be correlated with better reduction and maintaining the initial reduction. In contrast, Wang et al.[17] assumed that neither anatomic reduction nor maintenance of reduction was correlated with outcomes. Myerson et al.[18] suggested that primary arthrodesis may have a negative impact on the biomechanics of the foot, and therefore, did not recommend primary arthrodesis for athletes. However, in a retrospective study of 32 military personnel with Lisfranc injury, it was found that patients treated with PPA were able to return to full sporting activity 2 months earlier than those treated with ORIF. It was suggested that the higher rate of secondary surgery for implant removal in the ORIF group may have slowed the rehabilitation process and the return to military and sporting activity.[19] In the present study, although the functional status of the patients was not examined in detail, there were no significant differences between the patients treated with PAA or CRIF.

There were some limitations to this study, primarily the retrospective design. The lack of randomization and prospective follow-up of the patients could have resulted in bias. Another limitation was the lack of CT and weight-bearing X-ray of all the patients for a detailed evaluation of the reduction and arthrosis, which could be correlated with the outcomes of the patients.

Conclusion

This study demonstrated that both primary arthrodesis and fixation with minimally invasive techniques are suitable for the treatment of patients with Lisfranc injury after low-energy trauma. The patients with compromised soft-tissue envelope could be successfully treated with CRIF. The mean AOFAS scores were comparable between the two groups. Although there was no statistically significant difference, the mean pain and function scores were improved with closed reduction and fixation.

Ethics Committee Approval: This study was approved by the Şişli Hamidiye Etfal Training and Research Hospital Clinical Research Ethics Committee (Date: 22.12.2020, Decision No: 1743).

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Authorship Contributions: Concept: M.M.S., S.E.; Design: M.H.Ö., N.C.; Supervision: M.H.Ö.; Resource: M.M.S., S.E., N.C., M.H.Ö.; Materials: S.E., N.C.; Data: M.M.S., S.E., N.C., M.H.Ö.; Analysis: N.C., S.E.; Literature search: M.M.S.; Writing: M.M.S.; Critical revision: M.H.Ö.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Lisfrank yaralanmalarında iki cerrahi tekniğin karşılaştırılması; kapalı redüksiyon ve internal fiksasyona ile primer kısmi artrodez

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AMAÇ: Bu çalışmada, primer kısmi artrodez (PKA) veya kapalı redüksiyon ve internal fiksasyon (KRIF) ile tedavi edilen Lisfrank yaralanmalarının sonuçları karşılaştırıldı.

GEREÇ VE YÖNTEM: Düşük enerjili travma sonrası Lisfrank yaralanması nedeniyle PKA veya KRIF uygulanan hastaların geriye dönük bir incelemesi yapıldı ve radyografik ve klinik sonuçlar değerlendirildi.

BULGULAR: Ortalama yaşı 38 olan 45 hasta çalışmaya dahil edildi. Ortalama takip süresi 47 ay idi. Ortalama Amerikan Ortopedik Ayak ve Ayak Bileği Derneği (AOFAS) skoru PKA grubunda 83,6 ve KRIF grubunda 86.2 idi ($p>0.05$). Ortalama ağrı skoru PKA grubunda 32.9, KRIF grubunda 33.7 idi ($p>0.05$). KRIF grubunun %78'inde ve PPA grubunun %42'sinde semptomatik implant nedeniyle ikincil cerrahi gerekmiştir ($p<0.05$).

TARTIŞMA: Düşük enerjili Lisfrank yaralanmalarının primer kısmi artrodez veya kapalı redüksiyon ve fiksasyon ile tedavisi iyi klinik ve radyolojik sonuçlar vermiştir. Toplam AOFAS skorları açısından iki grup arasında anlamlı fark bulunamadı. Bununla birlikte, KRIF grubunda sekonder cerrahiye daha fazla ihtiyaç duyulurken, kapalı redüksiyon ve fiksasyon ile ağrı ve fonksiyonel skorlar daha yüksek gözlendi.

Anahtar sözcükler: Kapalı redüksiyon; Lisfrank yaralanmaları; orta ayak; primer kısmi artrodez.

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