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Open Reduction Internal Fixation vs Primary Arthrodesis for Lisfranc Fracture-Dislocations: A Cost Analysis

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Abstract

Background: Lisfranc fracture-dislocation is an uncommon but serious injury that currently lacks universal consensus on optimal operative treatment. Two common fixation methods are open reduction and internal fixation (ORIF) and primary arthrodesis (PA). The objective of this study is to analyze the cost difference between ORIF and PA of Lisfranc injuries, along with the contribution of medical services to overall costs.

Methods: This was a retrospective cost analysis of the MarketScan database from 2010 to 2020. MarketScan is an insurance and commercial claims database that integrates deidentified patient information. It captures person-specific clinical utilization, expenditures, and enrollment across inpatient and outpatient services. Patients undergoing primary ORIF (*CPT* code 28615) vs PA (28730 and 28740) for Lisfranc fracture-dislocation were identified. The primary independent variable was ORIF vs PA of Lisfranc injury. Total costs due to operative management was the primary objective. The utilization of and costs contributed by medical services was a secondary outcome.

Results: From 2010 to 2020, a total of 7268 patients underwent operative management of Lisfranc injuries, with 5689 (78.3%) ORIF and 1579 (21.7%) PA. PA was independently associated with increased net and total payment and coinsurance, clinic visits, and imaging, and patients attended significantly more PT sessions.

Conclusion: Using this large database that does not characterize severity or extent of injury, we found that treatment of Lisfranc fracture-dislocation with ORIF was associated with substantially lower initial episode of treatment costs compared with PA. Specific excessive cost drivers for PA were clinic visits, PT sessions, and imaging.

Level of Evidence: Level III, retrospective cohort study.

Keywords: Lisfranc fracture-dislocation, cost analysis, Marketscan, open reduction internal fixation, primary arthrodesis

Introduction

Lisfranc fracture-dislocations are uncommon but serious orthopaedic injuries, occurring at a rate of 1 per 55 000 annually in the United States and accounting for nearly 0.2% of all fractures.[12] Mechanisms of Lisfranc injuries can include direct and indirect forces from high-energy trauma, sporting injuries, and low-energy trauma.[28] Disruption of the tarsometatarsal joint complex occurs through purely ligamentous, purely osseous, or a combination of the 2 injuries.[6,22,27]

Operative management of Lisfranc injuries has been shown to produce better outcomes in the majority of patients.[4] However, optimal treatment for unstable Lisfranc injuries remains unclear in part due to the variations in injuries.[14,17] The aim of treatment is stable restoration of the longitudinal and transverse arches of the foot

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through 2 commonly accepted operative treatments: open reduction and internal fixation (ORIF) or primary arthrodesis (PA).[17,24] Both methods have advantages and disadvantages, though PA may be considered as the treatment of choice in pure ligamentous injuries.[23] Although previous studies have not demonstrated a significant difference, PA may demonstrate a trend towards less subsequent secondary surgery, less implant removal, and a faster return to activity, with some evidence of better functional outcomes,[5,7-9,11,13,16,18,21,24] preventing the need for secondary interventions and reducing the probability of developing posttraumatic arthritis.[5,9,13,20] ORIF risks development of secondary arthritis in 40% to 90% of patients and the possibility of costly secondary interventions such as removal of the osteosynthesis materials for pain relief or subsequent arthrodesis.[10,15] However, preserving patency of the midfoot joints through ORIF with staged removal of hardware may improve functional mobility and thereby quality of life.[23]

Similar debate is seen when comparing cost burden of PA to ORIF. Albright et al[1] found PA to be the preferred treatment strategy for ligamentous Lisfranc injuries in terms of cost-benefit analysis. Patients undergoing PA on average spent $43 192 less than the ORIF group, and when calculating the cost required to gain one additional quality-adjusted life-year (QALY), the cost in the PA group was $1429/QALY compared to $3958/QALY in the ORIF group.[1] In contrast, Barnds et al[2] found PA to have both a significantly higher average cost of care ($5005.82) compared with ORIF ($3961.97), and a higher complication rate for treating Lisfranc injuries. Whereas Albright et al focused on the cost effectiveness of PA vs ORIF, Barnds et al found that the cost comparison and complication rate may explain the differences in conclusion. These studies also used different databases, as Albright et al derived cost from 2017 Medicare fee schedules whereas Barnds et al investigated cost using the PearlDiver data set from 2007 to 2016. Consensus is yet to be established on which treatment carries a higher cost burden for Lisfranc injuries.

To date, no study has used a large commercially maintained database to understand the differences in cost burden between ORIF and PA for treating Lisfranc injuries. The objective of this study was to analyze the cost difference between ORIF and PA management of Lisfranc injuries in the US population. We hypothesized that ORIF will be cheaper compared to PA in all groups.

Methods

Data Source

Ethical approval was not sought for the present study because data for this retrospective analysis were collected from the IBM Marketscan database, which contains more than 215 million deidentified, individual-level private health insurance claims by beneficiaries, their spouses, or dependents enrolled by a participating employer, health plan, or government organization in the United States. Marketscan includes diagnosis codes, procedure codes, and associated costs, as well as demographic and other health-related data. This database has been used extensively in the field of orthopaedics in analyses of costs and spending.[3,19,25]

Patient Selection

Patients were included if they were diagnosed with a Lisfranc fracture-dislocation that was operatively managed with ORIF or PA from 2010 to 2020. Lisfranc injuries were identified using *International Classification of Diseases, Ninth* and *Tenth Revision* (ICD-9 and ICD-10), codes (838.03, S93.32). Operative management was determined by *Current Procedural Terminology* (*CPT*) codes 28615 for ORIF and 28730 and 28740 for arthrodesis. Patients were excluded if they did not receive either an ORIF or PA for Lisfranc injuries.

Study Variables and Outcome Measures

Patient age, gender, geographic region, employment status, and insurance information were collected. Insurance information extracted were plan type, in-network status, and number of encounters. Our primary independent variable was ORIF vs PA of Lisfranc injury. With respect to outcomes, the primary measure was overall costs accrued because of the operatively managed Lisfranc fracture-dislocation. These were net payment, total payment, coinsurance, copayment, deductible, and coordination of benefits per savings (COB/savings) amounts. The utilization of and costs contributed by medical services was a secondary outcome. These were outpatient clinic visits, foot radiographs, lower extremity magnetic resonance imaging, lower extremity computed tomography (CT), physical therapy (PT), and opioid prescriptions.

Statistical Analyses

Data were analyzed to compare costs associated with ORIF and PA of Lisfranc injury. Student *t* test was used for continuous variables, and χ^2 test was used for dichotomous variables. Poisson multivariable regression was further conducted to determine independent associations with cost, adjusting for the patient and insurance characteristics listed above.

Results

Patient Characteristics

From 2010 to 2020, a total of 7267 patients underwent operative management of Lisfranc fracture-dislocations. Of these patients, 5678 (78.1%) underwent primary ORIF and 1589 (21.9%) PA (Table 1).

Table 1. Patient Characteristics.[a]

	Total (N=7267)	Primary ORIF (n=5678)	Primary Arthrodesis (n=1589)	*P*
Age, y, mean ± SD	38.5 ± 15.3	36.9 ± 15.2	44.2 ± 14.1	<.001
Female	4023 (55.4)	3077 (54.2)	946 (59.5)	<.001
Geographic region				<.001
Northeast	1137 (15.6)	912 (16.1)	225 (14.2)	
North Central	1678 (23.1)	1244 (21.9)	435 (27.4)	
South	2985 (41.1)	2351 (41.4)	634 (39.9)	
West	1361 (18.7)	1086 (19.1)	275 (17.3)	
Unknown	106 (1.5)	86 (1.5)	20 (1.3)	
Employment status				<.001
Full-time	4082 (56.2)	3114 (54.8)	968 (60.9)	
Part-time	83 (1.1)	68 (1.2)	15 (0.94)	
Retiree	289 (4.0)	208 (3.7)	81 (5.1)	
Disability	28 (0.39)	23 (0.41)	5 (0.31)	
Dependent	10 (0.14)	9 (0.16)	1 (0.06)	
Other/unknown	2775 (38.2)	2256 (39.7)	519 (32.7)	
Plan type				.62
Basic	0 (0.0)	0 (0.0)	0 (0.0)	
Comprehensive	142 (2.0)	106 (1.9)	36 (2.3)	
EPO	91 (1.3)	76 (1.3)	15 (0.94)	
HMO	671 (9.2)	519 (9.1)	152 (9.6)	
POS	563 (7.7)	431 (7.6)	132 (8.3)	
PPO	4233 (58.2)	3325 (58.6)	908 (57.7)	
CDHP	654 (9.0)	510 (9.0)	144 (9.1)	
HDHP	537 (7.4)	409 (7.2)	128 (8.1)	
In-network services	6365 (87.6)	4946 (87.1)	1419 (89.3)	.01
Encounters, n, mean ± SD	24.5 ± 26.9	22.9 ± 25.9	30.1 ± 29.8	<.001

Abbreviations: CDHP, consumer-driven health plan; EPO, exclusive provider organization; HDHP, high-deductible health plan; HMO, health maintenance organization; ORIF, open reduction internal fixation; POS, point-of-service; PPO, preferred provider organization.
[a]Unless otherwise noted, values are n (%).

Table 2. Cost for ORIF vs Arthrodesis of Lisfranc Fracture-Dislocation.

	Total, Mean ± SD (N=7267)	ORIF, Mean ± SD (n=5678)	Primary Arthrodesis, Mean ± SD (n=1589)	*P*
Net payment*, $	7308.83 ± 10807.21	6378.63 ± 10035.09	10632.73 ± 12659.01	<.001
Total payment, $	8537.85 ± 11517.48	7570.15 ± 10705.84	11995.76 ± 13487.22	<.001
Coinsurance, $	602.29 ± 987.31	580.69 ± 930.96	679.48 ± 1163.72	<.001
Copayment, $	93.47 ± 278.70	90.58 ± 285.17	103.79 ± 254.04	.10
Deductible payment, $	338.81 ± 780.41	337.80 ± 765.28	342.40 ± 832.47	.84
COB/savings, $	115.33 ± 1317.20	115.20 ± 1340.24	115.78 ± 1231.77	.99

Abbreviations: COB, coordination of benefits; ORIF, open reduction internal fixation.
*Net employer payment = total payment − coinsurance − copayment − deductible − COB.

Cost for ORIF vs PA of Lisfranc Fracture-Dislocation

On multivariable analysis, PA of Lisfranc fracture-dislocation was independently associated with higher net payment (incidence rate ratio [IRR] 1.6, 95% CI 1.6-1.6), total payment (IRR 1.5, 95% CI 1.5-1.5), and coinsurance (IRR 1.2, 95% CI 1.2-1.2) ($P < .001$). Compared with ORIF, PA also had higher deductible ($90.58 ± 285.17 vs $103.79 ± 254.04) and copayment amounts ($337.80 ± 765.28 vs $342.40 ± 832.47), although these trends were not statistically significant (Table 2).

Table 3. Medical Service Costs for ORIF vs Arthrodesis of Lisfranc Fracture-Dislocation.

Medical Service	Total (N=7267)	ORIF (n=5678)	PA (n=1589)	*P*
Clinic visits				
Mean no.	0.94 ± 1.4	0.88 ± 1.3	1.2 ± 1.6	<.001
Net payment, $	65.09 ± 115.75	59.66 ± 108.97	84.50 ± 135.53	<.001
Radiographs				
Mean no.	1.8 ± 2.3	1.8 ± 2.2	1.9 ± 2.4	.02
Net payment, $	76.34 ± 320.77	69.24 ± 153.71	101.71 ± 620.89	<.001
Magnetic resonance imaging				
Mean no.	0.03 ± 0.19	0.03 ± 0.19	0.03 ± 0.19	.90
Net payment, $	14.24 ± 174.30	12.04 ± 112.30	22.12 ± 306.34	.04
Computed tomography				
Mean no.	0.07 ± 0.31	0.06 ± 0.29	0.11 ± 0.38	<.001
Net payment, $	21.89 ± 136.54	17.64 ± 123.19	37.08 ± 175.36	<.001
Physical therapy sessions				
Mean no.	2.8 ± 13.4	2.7 ± 13.1	3.4 ± 14.3	.04
PT duration, days	6.4 ± 34.3	5.7 ± 28.6	8.9 ± 49.4	<.001
Net payment, $	116.95 ± 648.18	108.47 ± 651.10	147.24 ± 636.91	.04
Opioid prescriptions				
Mean no.	0.94 ± 0.66	0.93 ± 0.65	0.97 ± 0.71	.37
Use duration, d	86.0 ± 397.3	76.4 ± 374.7	120.1 ± 467.8	<.001
Net payment, $	334.24 ± 5,846.04	321.79 ± 6,372.68	378.74 ± 3,345.35	.73

Abbreviations: ORIF, open reduction internal fixation; PA, primary arthrodesis; PT, physical therapy.

Medical Service Utilization and Costs for ORIF vs PA of Lisfranc Fracture-Dislocation

On multivariable analysis, PA of Lisfranc fracture-dislocation was independently associated with the utilization of more clinic visits (IRR 1.2, 95% CI 1.1-1.3), CT scans (IRR 1.6, 95% CI 1.3-1.9), PT sessions (IRR 1.2, 95% CI 1.2-1.3), and opioid prescription fills (IRR 1.2, 95% CI 1.1-1.3). Patients undergoing PA also accrued significantly higher net payments due to the following medical services: clinic visits (IRR 1.3, 95% CI 1.3-1.3), radiographs (IRR 1.4, 95% CI 1.4-1.4), magnetic resonance imaging scans (IRR 1.9, 95% CI 1.8-1.9), CT scans (IRR 2.0, 95% CI 2.0-2.0), and PT sessions (IRR 1.3, 95% CI 1.2-1.3). Despite significance on univariate analysis, PA of Lisfranc fracture-dislocation was not independently associated with number of radiographs. Compared with ORIF, duration of PT (8.9 ± 49.4 vs 5.7 ± 28.6) days and opioid use (120.1 ± 467.8 vs 76.4 ± 374.7) days were also significantly longer for PA (Table 3).

Discussion

There is as yet little evidence establishing a compelling difference in outcomes between ORIF and PA for Lisfranc injuries. Better understanding of the cost burden between these 2 treatments may help to elucidate optimal management of Lisfranc injuries. In this study based on the commercially available MarketScan database, we found that primary ORIF was independently associated with initial episode of care lower net and total payments. After ORIF patients attended less clinic visits, had less imaging, and attended less PT sessions compared to PA. Based on these findings, orthopaedic surgeons may consider the initial episode of care increased cost burden of primary PA relative to ORIF in determining the course of treatment for Lisfranc injuries.

Broadly, our results align with previous findings from Barnds et al[2] that PA is associated with higher costs than ORIF. Our results expand on this finding by specifically highlighting the key drivers of this cost discrepancy. Specifically, PA of Lisfranc fracture-dislocation was independently associated with increased net payment, total payment, and coinsurance. Our results stand in contrast to Albright et al,[1] who found that patients undergoing PA on average spent $43 192 less than the ORIF group and had less costs in terms of QALYs compared with the ORIF group. However, this discrepancy can be addressed by several factors. First, our study focused on direct cost comparisons whereas Albright et al investigated cost effectiveness. Second, our data reflected private insurance whereas those of Albright et al were derived from Medicare payment schedules. Albright et al[1] specifically investigated health care system cost as a whole, using costs derived from the relevant data and use Medicare 2017 fee schedules.

There are possible reasons for these differences in costs between PA and ORIF. Notably, patients undergoing PA had on average a higher number of encounters (30.1 ± 29.8) compared with those undergoing primary ORIF (22.9 ± 25.9) ($P < .001$). This could be a potential driver of increased costs, with additional office visits including more

PT sessions, imaging, and other services contributing to the overall cost discrepancy. However, this study found no difference between several subcosts, including deductible and copayment, between the 2 groups. This similarity was especially seen in postoperative treatment including number and costs of opioid prescriptions. There are no reports in the literature discussing the similarities in PT and opioid usage between patients undergoing either PA or ORIF for Lisfranc injury. A hypothetical reason for the similarity in PT usage may be that despite these differences in surgical management, Lisfranc injuries may benefit from a course of PT focusing on gait and balance.[26] However, because no formal study exist on the differences in the pain management between these 2 treatment strategies postoperatively, there is an opportunity for future studies to understand these differences.

Although the results of this study may represent a valuable addition to the literature around cost burden of 2 different treatment methods for Lisfranc injuries, there are several key limitations. First, this study used an insurance and commercial claims database, and thus the data integrity is dependent on the accuracy of coding upon data entry. Similarly, there is annual variation in the population based on insurance, employment status, and other variables assessed that may have affected patients' presence or absence from the database. Additionally, the analysis was limited by the variables available in the data set, which were defined in terms of demographic and clinical details. Unfortunately, the MarketScan database does not include variables such as how many tarsometatarsal joints were involved in a Lisfranc fracture-dislocation, and the mechanism and severity of the injury. The database only differentiates hospital type based on either inpatient or outpatient and does not provide any information on if the institution is a community, trauma, academic, or referral center. Differences in functional outcomes may contribute to the overall cost-effectiveness of a given procedure, and functional outcomes were not available for analysis. Demographic and clinical details may influence procedural decision making, and the results of this study should be considered in tandem with such details. Only procedural code 28615 was used to identify ORIF, but this may not have captured all patients since other common codes for Lisfranc treatment. For example, 28485 may also be used for unrelated pathology. Finally, differing hardware constructs (screws vs screws + plates) may have been used between the 2 groups, and this could have substantially affected the cost analysis.

Conclusion

When compared to ORIF, PA Initial episode of care treatment for Lisfranc fracture-dislocation is associated with increased net payment, higher postoperative costs including higher clinic net pay and increased number of clinic visits, higher radiograph, magnetic resonance imaging, and CT net payments, and a higher number of CT scans. With these 2 primary procedures being near equivalent in clinical outcomes, these findings should be considered when planning operative interventions for these injuries.

Ethical Approval

Ethical approval was not sought for the present study because data for this retrospective analysis were collected from the IBM Marketscan database, which contains more than 215 million deidentified, individual-level private health insurance claims.

Declaration of Conflicting Interests

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