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Outcome After Open Reduction and Internal Fixation of Lisfranc Joint Injuries*

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Abstract

Background: **Open reduction and internal fixation has been recommended as the treatment for most unstable injuries of the Lisfranc (tarsometatarsal) joint. It has been thought that purely ligamentous injuries have a poor outcome despite such surgical management.**

Methods: **We performed a retrospective study of patients who underwent open reduction and screw fixation of a Lisfranc injury in a seven-year period. Among ninety-two adults treated for that injury, forty-eight patients with forty-eight injuries were followed for an average of fifty-two months (range, thirteen to 114 months). Fifteen injuries were purely ligamentous, and thirty-three were combined ligamentous and osseous. Patient outcome was assessed with use of the American Orthopaedic Foot and Ankle Society (AOFAS) midfoot score and the long-form Musculoskeletal Function Assessment (MFA) score.**

Results: **The average AOFAS midfoot score was 77 points (on a scale of 0 to 100 points, with 100 points indicating an excellent outcome), with patients losing points for mild pain, decreased recreational function, and orthotic requirements. The average MFA score was 19 points (on a scale of 0 to 100 points, with 0 points indicating an excellent outcome), with patients losing points because of problems with "leisure activities" and difficulties with "life changes and feelings due to the injury." Twelve patients (25 percent) had posttraumatic osteoarthritis of the tarsometatarsal joints, and six of them required arthrodesis. The major determinant of a good result was anatomical reduction ($p = 0.05$). The subgroup of patients with purely ligamentous injury showed a trend toward poorer outcomes despite anatomical reduction and screw fixation.**

Conclusions: **Our results support the concept that stable anatomical reduction of fracture-dislocations of the Lisfranc joint leads to the best long-term outcomes as patients so treated have less arthritis as well as better AOFAS midfoot scores.**

In the treatment of fracture-dislocations of the tarsometatarsal joints, early accurate diagnosis combined with prompt anatomical reduction and stable internal fixation provides optimal results[1,5,7,19-21,24]. Closed reduction and percutaneous Kirschner-wire fixation has been advocated by some authors[3,9,13,19,30], but the trend is toward open reduction and screw fixation[1,5,7,20,24]. It has been observed that pure dislocations without fracture may be associated with a poorer outcome despite open reduction and internal fixation[12]. The purpose of this study was to analyze the results of open reduction and internal fixation of injuries of the tarsometatarsal joints, particularly those consisting of purely ligamentous disruption without fracture.

Materials and Methods

We performed a retrospective study of all patients with a tarsometatarsal joint injury treated at Harborview Medical Center between 1990 and 1997. Inclusion criteria were skeletal maturity and open reduction and internal fixation of a Lisfranc joint injury. Indications for surgery were instability, displacement of at least one millimeter in any plane, and purely ligamentous injury. Stability was assessed on stress radiographs or fluoroscopy, with the examiner looking for at least one millimeter of malalignment of the medial column line[6] and/or loss of the colinear relationship of the second metatarsal and the middle cuneiform on the anteroposterior radiograph and of the fourth metatarsal and the cuboid on the oblique radiograph[29]. Ninety-two adults with surgically treated injuries were identified from the trauma registry database and were contacted by mail or telephone. Forty-four patients were not available: twenty-three could not be contacted by mail or telephone, eight had inadequate medical records, seven lived out of state, four were not willing to participate, and two were incarcerated. This group was not significantly different from the study group with respect to injury-related data or treatment ($p = 0.61$). This left forty-eight patients with a total of forty-eight Lisfranc injuries available for clinical review. All patients gave informed consent for participation, and the Human Subjects Research Committee approved the study.

There were thirty-two male patients and sixteen female patients. The age range was from fifteen to seventy-seven years, with an average age of thirty-nine years. The left foot was involved in thirty-one patients and the right foot, in seventeen. Most (thirty-three) of the injuries were due to high-energy trauma. Twenty patients had been injured in a motor-vehicle accident, six had crush injuries, and seven had fallen from a height. Eight patients had been injured at work. There were twenty-three isolated Lisfranc injuries. Five patients had multiple trauma (an

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TABLE I
SUMMARY OF PATIENT DATA*

Case	Age *(yrs.)*	Cuneiform Injury	Cuboid Fracture	Metatarsal Base Fractures	Involved Tarsometatarsal Joints *(no.)*	Duration of Follow-up *(mos.)*	Reduction	Implant Failure	Posttraumatic Osteoarthritis	MFA Score *(points)*	AOFAS Score *(points)*
1	65	No	No	No	5	79	Anatomical	No	No	9	85
2	22	Yes	Yes	Yes	5	32	Nonanatomical	No	No	15	78
3	70	No	No	Yes	3	26	Anatomical	Yes	No	35	65
4	30	No	Yes	Yes	5	81	Anatomical	No	No	3	80
5	25	No	No	No	3	35	Anatomical	Yes	No	6	90
6	33	Yes	No	Yes	5	13	Anatomical	No	No	55	43
7	26	No	No	Yes	2	58	Anatomical	No	No	5	93
8	68	No	No	No	2	60	Anatomical	No	Yes	39	65
9	37	No	No	No	2	21	Anatomical	No	No	7	98
10	35	Yes	No	No	5	25	Anatomical	Yes	Yes	38	47
11	22	No	No	No	5	91	Anatomical	Yes	Yes	1	100
12	66	Yes	No	Yes	5	18	Anatomical	Yes	No	3	90
13	33	Yes	No	Yes	5	18	Nonanatomical	No	Yes	20	42
14	41	No	Yes	Yes	5	31	Anatomical	Yes	Yes	38	40
15	39	Yes	No	Yes	5	67	Nonanatomical	No	No	15	73
16	42	No	No	Yes	5	43	Anatomical	No	Yes	22	41
17	61	No	No	No	2	114	Nonanatomical	No	Yes	45	60
18	37	No	Yes	No	2	43	Anatomical	No	No	23	85
19	55	Yes	Yes	Yes	5	103	Anatomical	No	No	17	97
20	29	No	No	No	2	72	Anatomical	No	No	22	80
21	32	No	No	No	5	70	Anatomical	No	No	0	100
22	61	Yes	No	No	5	27	Nonanatomical	Yes	No	11	80
23	77	No	Yes	Yes	5	95	Anatomical	Yes	No	2	100
24	17	No	No	No	2	99	Anatomical	No	No	0	100
25	52	No	No	Yes	4	90	Anatomical	No	No	0	100
26	15	Yes	No	No	5	18	Anatomical	No	No	5	82
27	59	No	No	Yes	2	59	Nonanatomical	No	Yes	41	61
28	33	Yes	No	Yes	5	84	Nonanatomical	No	Yes	39	63
29	25	No	No	Yes	5	59	Nonanatomical	No	No	12	80
30	22	No	No	No	5	56	Anatomical	No	No	1	100
31	19	No	No	Yes	5	69	Anatomical	Yes	No	2	83
32	17	No	Yes	Yes	5	81	Anatomical	No	No	8	95
33	31	Yes	No	Yes	5	45	Anatomical	No	No	22	78
34	50	Yes	No	No	5	15	Anatomical	No	No	43	80
35	60	Yes	Yes	Yes	5	96	Anatomical	Yes	No	6	90
36	28	No	No	Yes	5	70	Anatomical	No	No	4	82
37	35	No	No	Yes	5	73	Anatomical	No	No	32	85
38	45	Yes	No	Yes	5	13	Anatomical	Yes	No	36	65
39	48	No	No	Yes	5	43	Anatomical	No	No	27	77
40	36	Yes	No	Yes	3	18	Anatomical	No	No	3	85
41	39	No	No	Yes	5	35	Anatomical	No	No	3	80
42	52	No	Yes	Yes	5	21	Anatomical	No	No	22	73
43	36	Yes	No	Yes	5	26	Anatomical	Yes	No	38	58
44	17	Yes	No	Yes	5	92	Nonanatomical	No	Yes	32	65
45	32	No	No	Yes	5	58	Nonanatomical	No	Yes	28	60
46	37	No	No	No	5	23	Anatomical	No	Yes	31	70
47	26	No	No	No	5	33	Anatomical	No	No	34	82
48	24	Yes	No	No	2	18	Anatomical	No	No	11	90

*MFA = Musculoskeletal Function Assessment, and AOFAS = American Orthopaedic Foot and Ankle Society.

Injury Severity Score[2] of at least 18 points), ten patients sustained a fracture or fractures of the ipsilateral lower extremity, and eight sustained a fracture or fractures of the contralateral lower extremity (Table I).

There were forty-two closed injuries and six open injuries. The open injuries were classified according to the method of Gustilo and Anderson[11]; no injuries were type I, one was type II, two were type IIIA, and three were type IIIB. Thirty-five patients had involvement of all five tarsometatarsal joints, one had involvement of four, three had involvement of three, and nine had involvement of two. Seven injuries involved the medial column (the first and second tarsometatarsal joints) alone, and two involved the lateral column (the fourth and fifth tarsometatarsal joints) alone. Two patients (Cases 2 and 18) required fasciotomy because of impending compartment syndrome of the foot.

FIG. 1-A

FIG. 1-B

Figs. 1-A, 1-B, and 1-C: Radiographs showing the internal fixation of injuries of the Lisfranc (tarsometatarsal) joint. Two screws are placed in opposite directions across the first tarsometatarsal joint, one is placed across the second tarsometatarsal joint, and one is placed across the third tarsometatarsal joint. A fifth screw, the so-called Lisfranc screw, is placed from the medial cuneiform to the base of the second metatarsal. One or two Kirschner wires are used to stabilize the fourth and fifth tarsometatarsal joints.

Figs. 1-A and 1-B: Anteroposterior and oblique radiographs.

Thirty patients had fractures of the bases of the metatarsals. Eighteen patients had associated cuneiform fractures or disruptions, and nine had associated cuboid fracture. Thirty-three patients had combined ligamentous and osseous injuries, and fifteen had ligamentous injury only (no fracture). Patients with only a fleck sign[19] (an avulsion fracture of the Lisfranc ligament[14]) were considered to have purely ligamentous injury. The direction of displacement was lateral in thirty-nine patients, medial in two, and divergent in seven. For three patients, the diagnosis was delayed for more than one month.

Final weight-bearing radiographs were reviewed for evidence of fracture nonunion, malalignment, posttraumatic osteoarthritis, or implant failure. Nonunion was defined as no healing of the fracture after three months. Several radiographic parameters were used to assess alignment. In the normal foot, the medial border of the second metatarsal is colinear with the medial border of the middle cuneiform on the anteroposterior radiograph. On the oblique radiograph, the medial border of the fourth metatarsal is colinear with the medial border of the cuboid and the lateral border of the third metatarsal is colinear with the lateral border of the lateral cuneiform[29]. On the lateral radiograph, the cortices of the cuneiforms and their respective metatarsals should form an unbroken line. The lateral talometatarsal angle was also used to evaluate sagittal deformity[27].

FIG. 1-C

Lateral radiograph.

FIG. 2-A

FIG. 2-B

Figs. 2-A through 2-H: Case 11, a patient who sustained a purely ligamentous Lisfranc injury. Posttraumatic osteoarthritis developed, requiring arthrodesis twelve months after the open reduction and internal fixation procedure.

Figs. 2-A and 2-B: Preoperative anteroposterior and lateral radiographs showing dorsolateral displacement of all five tarsometatarsal joints.

This angle is formed by the intersection of a line along the long axis of the talus with the long axis of the first metatarsal and should be a straight line. In the normal foot, a line tangential to the medial aspect of the navicular and the medial cuneiform (the medial column line) should intersect the base of the first metatarsal on an abduction stress anteroposterior radiograph[6]. The reduction was considered anatomical if this relationship was intact, nearly anatomical if it was within two millimeters, and nonanatomical if it was off by greater than two millimeters. Posttraumatic osteoarthritis was assessed clinically and on weight-bearing radiographs and was deemed to be present if there was any radiographic evidence of osteophytes, joint-space narrowing, or subchondral cysts or sclerosis in conjunction with tarsometatarsal joint pain and tenderness and pain with joint motion. The degree of posttraumatic osteoarthritis was classified according to the symptoms. Intermittent pain requiring intermittent use of over-the-counter analgesics was classified as mild, intermittent pain requiring use of regular prescriptive analgesics was classified as moderate, and constant chronic pain requiring use of stronger prescriptive analgesics was classified as severe.

At the time of final follow-up for the purposes of this study, the patients' charts were reviewed to identify all complications. Also, a

FIG. 2-C

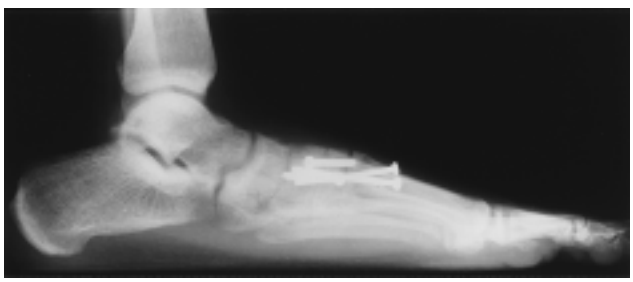

FIG. 2-D

Figs. 2-C and 2-D: Postoperative anteroposterior and lateral radiographs showing anatomical reduction and screw fixation.

FIG. 2-E

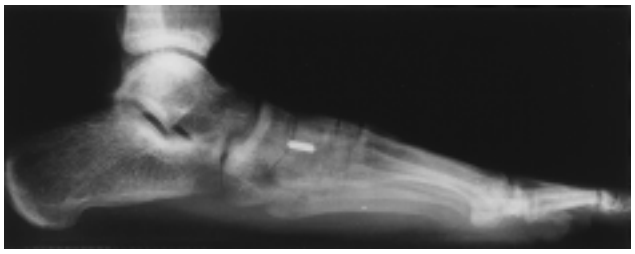

FIG. 2-F

Figs. 2-E and 2-F: Anteroposterior and lateral radiographs, made six months postoperatively, showing remnants of a broken screw and degenerative joint changes. The patient required arthrodesis of the medial two tarsometatarsal joints and the medial and middle intercuneiform joint because of painful posttraumatic osteoarthritis.

history was recorded and a physical examination was performed for all forty-eight patients. Functional outcomes were assessed with use of the American Orthopaedic Foot and Ankle Society (AOFAS) score[15] for the midfoot and the long-form Musculoskeletal Function Assessment (MFA) score[17]. The AOFAS score is based on a scale of 0 to 100 points, with 100 points indicating an excellent or maximum outcome. This score was determined by two of us (R. S. K. and S. K. H.), with one of us (S. K. H.) blinded. The MFA score is also based on a scale of 0 to 100 points, but 0 points indicates an excellent outcome. The MFA score is determined with use of a self-administered questionnaire and has been validated for use for evaluation after trauma[8]. The clinical and radiographic results and functional outcomes were analyzed to evaluate the effect of a variety of injury and treatment parameters. The Student t test was used to compare the AOFAS and MFA scores within subgroups, and the chi-square test was used to compare the prevalences of posttraumatic osteoarthritis between subgroups. A p value of 0.05 or less was considered significant.

Operative Technique

Open injuries were treated with immediate irrigation and débridement accompanied by open reduction and internal fixation or staged temporary external fixation with later open reduction and in-

FIG. 2-G

FIG. 2-H

Figs. 2-G and 2-H: Anteroposterior and lateral radiographs made twelve months after the arthrodesis.

TABLE II
SUMMARY OF OUTCOME SCORES*

Group	No. of Patients	Average AOFAS Score *(points)*	Average MFA Score *(points)*	Percentage of Patients with Posttraumatic Osteoarthritis
Open reduction and internal fixation	42	80.2	18	14
Secondary arthrodesis	6	58.2	25.7	100
Total series	48	77	19	25

*AOFAS = American Orthopaedic Foot and Ankle Society, and MFA = Musculoskeletal Function Assessment.

ternal fixation. Operative treatment of closed injuries was delayed until soft-tissue swelling subsided, which usually occurred within two weeks, unless there were increased compartment pressures and urgent fasciotomies were done. Compartment pressures were measured if there was a clinical suspicion that they were increased.

Operative reduction and fixation proceeded from a medial to a lateral direction (Figs. 1-A, 1-B, and 1-C). The first and second tarsometatarsal joints were approached through a single dorsal incision over the first intermetatarsal space. The branches of the superficial and deep peroneal nerves and the dorsalis pedis artery were preserved, and the first and second metatarsocuneiform joints were opened and irrigated. Comminuted fragments were reduced when possible; smaller, irreducible fragments were removed. The first tarsometatarsal joint was aligned by reducing the medial border of the medial cuneiform to the medial border of the first metatarsal. The plantar-medial aspect of the joint was directly visualized to ensure that there was no plantar gap. The joint was held reduced with a provisional Kirschner wire, and then one 3.5-millimeter transarticular countersunk cortical set screw was inserted from the metatarsal base proximally into the medial cuneiform, with care being taken to avoid violating the adjacent naviculocuneiform joint. If instability persisted, an additional 3.5-millimeter screw was placed from proximal to distal and lateral to the first screw to add rotational stability.

The second metatarsal was then reduced to the medial border of the middle cuneiform and was held provisionally with a Kirschner wire. A 3.5-millimeter countersunk cortical screw was placed from distal to proximal across the joint. An additional 3.5-millimeter cortical set screw (the Lisfranc screw) was inserted under biplanar fluoroscopy from the medial cuneiform into the base of the second metatarsal to increase the stability of the fixation. This Lisfranc screw was placed in the line of the interosseous Lisfranc ligament[14].

When the third metatarsal base was dislocated, a second dorsal incision was made between the third and fourth metatarsals to expose the third metatarsocuneiform joint. This joint was then reduced and was stabilized with a 3.5-millimeter screw from a distal to a proximal direction.

The fourth and fifth tarsometatarsal joints usually reduced once the above three reductions were achieved, and they were held with one or two transarticular percutaneous smooth Kirschner wires from the base of the fifth metatarsal into the cuboid[28]. Open reduction of these lateral two joints was required in only four patients.

To supplement this standard approach because of excessive comminution or persistent instability, supplementary smooth Kirschner-wire fixation was used in thirty-five patients; supplementary 2.7-millimeter cortical screws, in ten; and a joint-spanning one-quarter tubular plate (usually because of comminution of the second metatarsal base), in nine. Associated cuneiform or cuboid fracture required reduction and fixation with Kirschner wires, screws, a plate and screws[25], or a combination of these implants.

The alignment of the fractures and tarsometatarsal joints and the position of the implants were checked with fluoroscopy and intraoperative radiographs. Each foot was also examined clinically after fixation to assess the stability of the medial and lateral columns. Plantar alignment of the metatarsal heads was also checked. A short leg splint was applied at the end of the procedure with the ankle in the plantigrade position. It was worn for two weeks, and then a short leg non-weight-bearing cast was worn for an additional four weeks. At six weeks, the percutaneous lateral Kirschner wires were removed. The patients were then advanced to full weight-bearing in a walking boot over four to six weeks. The internal fixation was removed only if it was painful. Twenty-eight patients had the screws removed at an average of twelve months (range, three to thirty-six months) postoperatively. The indications for secondary tarsometatarsal arthrodesis were severe pain and disability in patients with posttraumatic osteoarthritis.

Results

The average duration of follow-up was fifty-two months (range, thirteen to 114 months).

Complications

Twelve patients (25 percent) had thirteen broken screws (Table I); five of these screws were across the first tarsometatarsal joint, two were across the second, and six were across the third. There were no postoperative infections. Two open fractures and one fasciotomy wound required split-thickness skin-graft coverage, and two other fractures required flap coverage. A deep-vein thrombosis developed in one patient. No painful neuromas or cases of reflex sympathetic dystrophy, vascular insufficiency, or stress fracture were noted.

Mild lateral subluxation developed in two patients once weight-bearing resumed, and posttraumatic arthritis developed in both of them. Mild arthritis developed at eight years in one of these patients, and moderate arthritis developed at 9.5 years in the other.

Posttraumatic Osteoarthritis

There were twelve patients (25 percent) with posttraumatic osteoarthritis, and six of them elected to undergo arthrodesis because of persistent pain. The average time from the index operation (open reduction and internal fixation) to the arthrodesis was twelve months (range, five to twenty-five months), and the duration of follow-up after the arthrodesis averaged forty months (range, five to eighty-five months). The average AOFAS and MFA scores for the patients who had an arthrodesis were 58.2 points (range, 40 to 100 points) and 25.7 points (range, 1 to 41 points), respectively (Table II). However, three of the six patients were assessed within thirteen months after the arthrodesis, and this may have affected the outcome scores. Comparison within subgroups (Table III) showed that the patients with nonanatomical reduction had a significantly higher prevalence of posttrau-

TABLE III
COMPARISON OF THE PREVALENCES OF POSTTRAUMATIC OSTEOARTHRITIS WITHIN SUBGROUPS

Subgroup	No. of Patients (N = 48)	Presence of Posttraumatic Osteoarthritis		
		No. of Patients	Percentage of Patients	P Value
Pure ligamentous injury	15	6	40	0.11
Combined ligamentous and osseous injury	33	6	18	
Open injury	6	2	33	0.61
Closed injury	42	10	24	
5 tarsometatarsal joints injured	35	9	26	0.52
<5 tarsometatarsal joints injured	13	3	23	
Cuneiform and/or cuboid injury	24	5	21	0.51
No cuneiform or cuboid injury	24	7	29	
Isolated injury	23	7	30	0.40
Multiple injuries	25	5	20	
Multiple trauma	5	1	20	0.79
No multiple trauma	43	11	26	
Ipsilateral fracture present*	10	3	30	0.84
No ipsilateral fracture present*	30	8	27	
Nonanatomical reduction	10	6	60	0.004
Anatomical reduction	38	6	16	
Delayed diagnosis	3	1	33	0.73
Acute diagnosis	45	11	24	
Work-related injury	8	3	38	0.37
Non-work-related injury	40	9	23	

*Eight patients with associated injury of the contralateral lower extremity were excluded from these groups.

matic osteoarthritis than did those with anatomical reduction (60 compared with 16 percent, p = 0.004). While there was a trend toward a higher prevalence of osteoarthritic change in the group with purely ligamentous injury compared with the group with combined ligamentous and osseous injuries (40 compared with 18 percent), this difference was not found to be significant (p = 0.11) (Figs. 2-A through 2-H). With the numbers available, the development of posttraumatic arthritis was not found to be associated with open injury, the number of tarsometatarsal joints involved, associated cuneiform or cuboid fracture, multiple injuries, multiple trauma, additional injury of the ipsilateral lower limb, delayed diagnosis, or work-related injury (Table III).

AOFAS and MFA Scores

The average AOFAS midfoot score was 77 points (range, 40 to 100 points), with patients losing points for mild pain, decreased recreational function, and the need to wear an orthotic in the shoe. The average MFA score was 19 points (range, 0 to 55 points), with patients losing points because of problems with "leisure activities" and difficulties with "life changes and feelings due to the injury" (Table II). When the six patients who underwent arthrodesis for symptomatic arthritis were eliminated, the remaining forty-two patients were found to have an average AOFAS midfoot score of 80.2 points (range, 43 to 100 points) and an average MFA score of 18 points (range, 0 to 55 points).

Analysis of the forty-two patients who did not have arthrodesis showed that the thirty-five patients with anatomical reduction had a higher average AOFAS score than the seven with nonanatomical reduction (82.1 compared with 70.6 points, p = 0.05). The average MFA score was also better (16.9 compared with 23.6 points, p = 0.3), but, with the numbers available, no significant difference could be detected (Table IV).

No significant difference in outcome scores could be detected when purely ligamentous injuries were compared with combined ligamentous and osseous injuries, open wounds were compared with closed wounds, involvement of five tarsometatarsal joints was compared with involvement of fewer than five, the presence of associated cuneiform and/or cuboid injury was compared with the absence of either injury, isolated injury was compared with multiple injuries, multiple trauma was compared with the absence of multiple trauma, the presence of associated injury of the ipsilateral lower limb was compared with the absence of such injury, acute diagnosis was compared with delayed diagnosis, and work-related injury was compared with non-work-related injury (Table IV).

Discussion

Lisfranc injuries account for 0.2 percent of all fractures[5,13,24]. They were classified by Quénu and Küss[23] into homolateral, divergent, and isolated groups. The system was later modified by both Hardcastle et al.[13] and Myerson et al.[19], who classified the injuries into total incongruity, partial incongruity, and divergent patterns. Although these classification systems were descriptive, we thought that they were not prognostic and that they

TABLE IV
COMPARISON OF THE AOFAS AND MFA SCORES WITHIN SUBGROUPS*

Subgroup	No. of Patients (N = 42)	AOFAS Score		MFA Score	
		Average *(points)*	P Value	Average *(points)*	P Value
Pure ligamentous injury	13	78.8	0.68	23.2	0.15
Combined ligamentous and osseous injury	29	80.8		15.7	
Open injury	4	78.3	0.78	26.8	0.24
Closed injury	38	80.4		17.1	
5 tarsometatarsal joints injured	30	78.5	0.25	18.7	0.66
<5 tarsometatarsal joints injured	12	84.3		16.3	
Cuneiform and/or cuboid injury	21	77.7	0.27	19.8	0.47
No cuneiform or cuboid injury	21	82.6		16.3	
Isolated injury	19	79.3	0.73	21	0.26
Multiple injuries	23	80.8		15.6	
Multiple trauma	4	76.3	0.57	16.8	0.8
No multiple trauma	38	80.6		18.8	
Ipsilateral fracture present†	9	72.3	0.3	19.1	0.8
No ipsilateral fracture present†	25	78.5		20.3	
Nonanatomical reduction	7	70.6	0.05	23.6	0.3
Anatomical reduction	35	82.1		16.9	
Delayed diagnosis	2	79	0.91	19	0.93
Acute diagnosis	40	80.2		18	
Work-related injury	6	85.5	0.33	19.2	0.85
Non-work-related injury	36	79.3		17.8	

*AOFAS = American Orthopaedic Foot and Ankle Society, and MFA = Musculoskeletal Function Assessment.
†Eight patients with associated injury of the contralateral lower extremity were excluded from these groups.

did not direct treatment decisions. Therefore, we classified the injuries anatomically and treated operatively those that demonstrated instability or displacement or that involved ligaments only.

Anatomical reduction and stable internal fixation has become a standard principle governing treatment of tarsometatarsal fracture-dislocations. Most authors have agreed that stable anatomical reduction leads to optimal results[1,7,19,20,24]. Our study supports this concept as patients with anatomical reduction had a significantly better average AOFAS score ($p = 0.05$) and a significantly lower prevalence of secondary osteoarthritis ($p = 0.004$). The advantage of open reduction is that it allows direct visualization of the fracture-dislocation for the débridement of comminuted fracture fragments, soft tissue, and osteochondral debris. This facilitates precise reduction of the injury.

There is controversy about which method of fixation is best. There are proponents of Kirschner-wire fixation[3,9,13,19,30], while others rely on screw fixation[1,5,7,20,24]. In an earlier study, we found a high rate of failure when Kirschner wires were used[26]. Since then, we have employed rigid fixation in the medial column. Screw fixation is stronger and allows a more stable construct. In our study, screws were placed without compression (set screws). We thought that compression across a reduced joint was unnecessary and that it increased the risk of degenerative changes developing. We wanted the screws to maintain the corrected joint position in order to allow the fractures and soft tissues to heal. Fractures healed well with this method, but ligamentous healing was probably less predictable. The purely ligamentous injuries did not always heal, and there was a trend toward an increase in degenerative changes. Despite the increased strength of the 3.5-millimeter cortical screws, breakage still occurred unless healing took place. Screws across the third tarsometatarsal joint failed the most often. This was most likely due to the close proximity of the third tarsometatarsal joint to the more mobile fourth and fifth tarsometatarsal joints[20,22]. Screws across the first tarsometatarsal joint had the second-highest prevalence of failure. Early in the study, only one screw was placed (from a distal to a proximal direction), but the addition of a second screw (from proximal to distal) added rotational stability, prevented plantar gapping, and decreased the rate of screw breakage.

It has been reported that the degree of posttraumatic arthritis is directly proportional to the degree of gross damage to the articular surface that had been identified at the operation and to the adequacy of reduction[19,26]. Our study supports this observation as patients with anatomical reduction had a significantly lower prevalence of posttraumatic osteoarthritis ($p = 0.004$) and a significantly better average AOFAS outcome score ($p = 0.05$) than did patients without anatomical reduction. Patients with purely ligamentous injury also had a trend toward a higher prevalence of posttraumatic osteoarthritis compared with patients with combined ligamentous and osseous injuries (40 compared with 18 percent, $p = 0.11$). Even when they had been

treated with anatomical reduction and screw fixation, patients with purely ligamentous injury still had a trend, although not a significant one, toward a higher rate of degenerative sequelae compared with patients with combined ligamentous and osseous injuries who had been treated with anatomical reduction and screw fixation. This suggests that the injury, rather than the treatment, has more influence on the outcome. Primary arthrodesis for the treatment of Lisfranc injuries has been advocated by Granberry and Lipscomb[10] and by Bonnel and Barthélémy[4], and this may be a better option for patients with purely ligamentous injury. However, new studies must be done to confirm this concept.

There are numerous outcome measurements that can be used to evaluate the results of treatment[8,15,17-19]. To measure functional outcome, we used the AOFAS midfoot scoring system as it is a well accepted and standard method for reporting results, and we also used the MFA scoring system because of its demonstrated validity in the evaluation of injured patients[8,17,18]. The average overall score for the forty-two patients who underwent open reduction and internal fixation in our study may be artificially elevated as the scores for the six patients requiring subsequent arthrodesis were excluded. Presumably, all six patients had poorer outcome scores prior to the arthrodesis, but we could not assess this retrospectively.

The outcome scores for the six patients who elected to have a secondary arthrodesis because of posttraumatic osteoarthritis were poor (average AOFAS midfoot score, 58.2 points; average MFA score, 25.7 points), perhaps because the follow-up period after the arthrodesis was short for three of the six patients. A temporarily poorer outcome can be expected in the first year after arthrodesis because recovery takes time[31]. Overall, the results of arthrodesis are not excellent. Myerson et al.[19] reported that patients had only fair long-term results after arthrodesis for the treatment of Lisfranc injuries. Komenda et al.[16] reported an average AOFAS score of 78 points in a study of thirty-two patients followed for an average of fifty months after the treatment of traumatic injury of the tarsometatarsal joints with arthrodesis.

One of the limitations of our study was the follow-up rate of only 52 percent. A review of available medical records showed that nine of the forty-four patients lost to follow-up had complications. Five had posttraumatic osteoarthritis, which was moderate in four and mild in one, with one patient electing to have an arthrodesis. Four of these five patients had nonanatomical reduction.

In summary, there were few significant differences between the groups, although the populations were small enough to hide many type-II errors (failure to see a difference between the outcomes of two groups [when there actually is a difference] because the sample size is too small). The trends lead to several conclusions. First, the overall outcomes after surgical treatment of Lisfranc injuries are good, and usually patients have few limitations. Patients lost points from the AOFAS midfoot scores because of mild pain, decreased recreational function, and the need to wear an orthotic in the shoe. Points were lost from the MFA scores because of problems related to "leisure activities" and difficulties with "life changes and feelings due to the injury." Second, anatomical reduction remains important for a good long-term outcome. Finally, anatomical reduction may be less predictive of a good result in patients who have dislocation without fracture. It may be that injuries involving damage to the ligament-bone interface cannot heal with sufficient strength for the patient to regain stable long-term function. However, this question would best be answered by a prospective study.

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