Aetiology, treatment and outcome in Lisfranc joint dislocations and fracture dislocations

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Summary

The aetiology, treatment and outcome of Lisfranc joint dislocations and fracture dislocations (L) were analysed. From 1972–97, 101 L were treated (right: $n = 52$, left: $n = 49$, bilateral: $n = 8$). Pure joint dislocations (LD) were observed in 24 cases, fracture dislocations (LFD) in 55 cases and Chopart–Lisfranc fracture dislocations (CLFD) in 22 cases. A total of 85 L were operatively treated; 15 times with closed reduction and 70 times with open reduction. A total of 85 (84%) feet received internal fixation, and in 15 (15%) cases, an external fixator was utilized additionally. In total, 10 primary and 20 secondary arthrodeses were performed and 16 feet were treated non-operatively. A total of 62 patients had follow-up after 9 (1–25) years. The mean scores were: AOFAS-Midfoot = 72 (29–100), Hannover Scoring System = 66 (26–100). Under consideration of age, sex, injury cause, time and type of treatment, no significant score differences occurred. CLFD showed lower scores than LD and LFD. In LFD and CLFD, an initial and maintained anatomic reduction with internal fixation or added external fixation was essential for good results. The long-term results of L are characterized by high functional restrictions, which can most likely be minimized with early open reduction and internal fixation, especially in fracture dislocations.

***Keywords*:** Lisfranc dislocation; Lisfranc fracture dislocation; midfoot fracture; origin; treatment; long-term results

Introduction

Lisfranc joint dislocations or fracture dislocations are the most common severe injuries of the midfoot [1,2]. Lisfranc fracture dislocations account for 0.2% to 0.8% of all fractures [3,4]. As many as 20% of these injuries are misdiagnosed or overlooked, especially in the polytrauma patient with other distracting injuries [4]. Still, they are also problematic in treatment and result in a high degree of long-term morbidity [2,5–8]. Lisfranc joint dislocations and dislocation predominantly occur in motor vehicle collisions [2,9]. Despite significant improvements in automobile safety, the incidence and severity of midfoot injuries has remained the same [10–12].

We performed a clinical retrospective study involving patients treated in a Level I Trauma Center, to create a basis for treatment optimization and minimization of the long-term morbidity.

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Methods

The patients treated in the Trauma Department of the Hannover Medical School in Hannover/Germany with Lisfranc joint dislocations or fracture dislocations over a 25-year period (1972 to 1997) were evaluated.

Inclusion criteria

Traumatic dislocations or fracture dislocations of the Lisfranc joint were included (L, total group of all feet with Lisfranc joint dislocations or fracture dislocations). The injuries (L) were categorized in pure Lisfranc joint dislocations (LD), Lisfranc joint fracture dislocations (LFD) and combined Chopart–Lisfranc joint fracture dislocations (CLFD). The injuries were classified according to the Quenu and Küss Lisfranc dislocation classification (Figure 1) [13]. The soft tissue damage was classified according to Tscherne and Oestern [14] (Table 1). In addition to demographic data, the origin of the injuries, time from injury to treatment and method of treatment were registered.

Treatment

Non-operative (closed reduction, no internal fixation)

The indications for non-operative treatment were: (i) sufficient closed anatomic reduction; (ii) sufficient stability after reduction in anatomic position; and (iii) contraindications for operative treatment. The non-operative treatment was performed in a cast with partial weight bearing for 6 weeks.

Semi-operative (closed reduction, internal fixation)

When the closed reduction was successful but the reduced joints were not considered to be stable, an internal fixation, utilizing 1.6 to 2.0-mm K-wires or percutaneous 3.5-mm cortical screws, was used. A short leg-cast was applied in the operating room, and rehabilitation was performed in the cast with

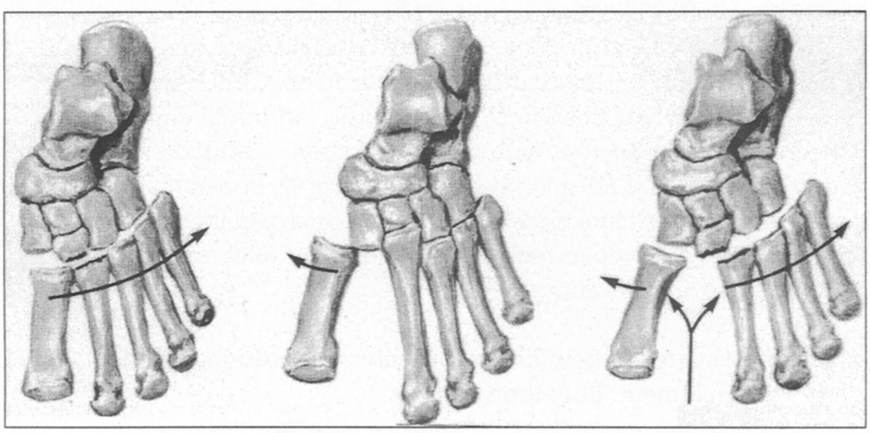

Figure 1
Quenu and Küss Lisfranc dislocation classification [13]: homolateral, isolated, divergent (from left to right).

Table 1
Classification of soft tissue injuries, according to Tscherne and Oestern, in closed and open fractures according to soft tissue damage, fracture severity and contamination [14]

Classification	*Skin:* (*Open* +, *closed* –)	*Soft tissue damage*	*Fracture severity:* (*Mild* +, *moderate* ++, *severe* +++)	*Contamination*
Fr. C 0	–	–	+	–
Fr. C I	–	+	+ to ++	–
Fr. C II	–	++	+ to +++	–
Fr. C III	–	+++	+ to +++	–
Fr. O I	+	+	+ to ++	+
Fr. O II	+	++	+ to +++	++
Fr. O III	+	+++	+ to +++	+++
Fr. O IV	+	+++	+ to +++	+ to +++

Soft tissue damage: –, absent or negligible; +, superficial abrasion or contusion; ++, deep abrasion, localized skin or muscle contusion; +++, extensive contusion. Contamination: +, minor contamination; ++, moderate contamination; +++, severe contamination.

partial weight bearing for 6 weeks. Hardware removal was performed at 6 weeks.

Operative (open reduction, internal fixation, optional additional external fixation)

In the remaining cases, an open reduction was performed. An open procedure was furthermore performed in all open injuries and, in all cases, with compartment syndrome. If a massive swelling without compartment syndrome was observed, the operative procedure was postponed until the swelling had gone down. In those cases, a closed reduction was initially performed and a short leg-cast was applied. Those patients were then treated with bed rest, elevation of the foot and cooling until the operation, and non-steroidal anti-inflammatory drugs (NSAIDs) were prescribed. A long dorsal median incision was used in the majority of the open procedures. For internal stabilization, 1.6 to 2.0-mm K-wires and/or 3.5-mm cortical screws were used. Normally, all rays were stabilized in a distal–proximal direction perpendicular to the Lisfranc joint surface for optimal stability. In cases with associated hindfoot or ankle instability, an external fixator between the tibia and first and fifth metatarsals was applied. A primary arthrodesis was performed in cases with massive or irreconstructable articular damage. When a primary skin closure was not possible, the skin defect was covered with artificial skin. Within 1 or 2 weeks, a secondary skin closure was normally possible and a skin graft was not necessary. A short leg-cast was applied in the operating room in all cases without an external fixator. Ambulation with partial weight bearing (15–30 kg) was performed when possible in the general condition of the patient. Hardware removal was performed at 6–10 weeks. When a primary arthrodesis was the aim, the screws were maintained for one year. Full weight bearing was allowed after 8–10 weeks.

Follow-up

The outcome was assessed by clinical examination and radiographs for the majority of the patients. Only patients whose treatment was completed at least 1 year before the time of follow-up were included in the outcome assessment. A part group of the patients underwent pedobarographic measurement using an EMED™ platform (Novel, Munich, Germany). The evaluation of the overall results was carried out with three different scoring systems: (i) the Hannover Scoring System (HSS) (Table 2); (ii) the Hannover Outcome-questionnaire (Q), rating patients' complaints and the functional status based on a severity–symptom scale and functional status [15]; and (iii) the American Foot and Ankle Society (AOFAS) Score [16]. The radiographs were evaluated by two orthopaedic surgeons independently (M.R., T.H). Length of the medial and lateral column (grades: correct or incorrect length as described by Zwipp [17]), shape of the longitudinal arch (grades: excellent, good, fair, poor; according to Paulos *et al.* [18]) and extent of arthritic changes in the Lisfranc joint (grades: absent, doubtful, minimal, moderate, severe; according to Kellgren and Lawrence [19]) were analysed and graded. Each case with deviation in any assessment ($n = 6$) was discussed by both observers and reassessed. The patients that could not be called back for clinical examination and radiographs were included in the follow-up by Q, obtained by telephone interview. The *t*-test and the χ^2-test were utilized for the statistical analysis of score differences (significance level: $P < 0.05$). The pedobarographic measurements were assessed qualitatively (grades: normal/near normal/abnormal/severely abnormal) with the standard software (pliance-m EXPERt v6. 3–4, Novel, Munich, Germany). Pressure value differences were statistically analysed with a *t*-test (significance level: $P < 0.05$).

Results

Demographics

A total of 93 patients with L were included. In the study group, men ($n = 64$, 69%) were affected twice as often as women ($n = 29$, 3%). The mean age at the time of injury was 28 years (16–78 years). The patients were primarily injured in traffic accidents (Figure 1).

Injury pattern

Both sides were affected equally (right: $n = 52$, left: $n = 49$), and eight (8.6%) patients sustained bilateral L. In total, 101 L were analysed. LD were observed in 24 (24%) cases, LFD in 55 (55%) and

Table 2
Hannover Scoring System (maximum 100 pts) [15]

Pain				
Pain during activity	1 = no (5 pts)	2 = yes (0 pts)		
Pain at rest	1 = no (5 pts)	2 = yes (0 pts)		
Sensitivity to changes in weather	1 = no (1 pt)	2 = yes (0 pts)		
Painful scar	1 = no (1 pt)	2 = yes (0 pts)		
Pain lateral ankle	1 = no (5 pts)	2 = yes (0 pts)		
Pain subtalar joint	1 = no (5 pts)	2 = yes (0 pts)		
Pain talonavicular joint	1 = no (3 pts)	2 = yes (0 pts)		
Pain calcaneocuboid joint	1 = no (3 pts)	2 = yes (0 pts)		
Pain forefoot	1 = no (5 pts)	2 = yes (0 pts)		
Assessment	1 = excellent (15 pts)	2 = good (12 pts)	3 = satisfactory (9 pts)	
Patient	4 = fair (6 pts)	5 = unsatisfactory (3 pts)	6 = poor	
Statics				
Scar	1 = bland (1 pt)	2 = livid (0 pts)	3 = celoid (0 pts)	
	4 = moist (0 pts)	5 = fistula (0 pts)		
Muscular problems	1 = none (2 pts)	2 = atrophy (1–0 pts)	3 = cramps (1–0 pts)	4 = muscular pain (1–0 pts)
Walking barefoot	1 = yes (5 pts)	2 = no (0 pts)		
Osseous problems	1 = none (2 pts)	2 = spur, ossification (0 pts)		
Ligamentous problems	1 = none (2 pts)	2 = tendinitis (0 pts)		
Statics hindfoot	1 = normal (2 pts)	2 = widened (1–0 pts)		
Statics forefoot	1 = normal (2 pts)	2 = equinus (1–0 pts)	3 = claw toe (1–0 pts)	
Longitudinal arch	1 = normal (2 pts)	2 = planus/clavus (1–0 pts)		
Dynamics				
Gait abnormality	1 = none (6 pts)	2 = minor (4 pts)	3 = evident (2 pts)	
	4 = considerable (0 pts)			
Subtalar joint motion	1 = 4/4 (6 pts)	2 = 3/4 (4 pts)	3 = 2/4 (2 pts)	
	4 = 1/4 (1 pt)	5 = 0/4 (0 pts)		
Chopart joint motion	1 = 4/4 (3 pts)	2 = 3/4 (2 pts)	3 = 2/4 (1 pt)	4 = 1/4 (0 pts)
Toe function	1 = 4/4 (3 pts)	2 = 3/4 (2 pts)	3 = 2/4 (1 pt)	4 = 1/4 (0 pts)
Calf circumference	1 = 1 cm side difference (2 pts)	2 = 2 cm (1 pt)	3 = 3 cm (0 pts)	
Proprioception	1 = 1 safe (2 pts)		2 = unsafe (1 pt)	3 = none (0 pts)
Footwear	1 = ready-to-wear shoes (3 pts)	2 = insole (2 pts)		
	3 = orthopaedic shoe(1 pt)	4 = boot (0 pts)		
X-Ray				
Arthritis subtalar joint	1 = none (4 pts)	2 = 1° (2 pts)	3 = 2° (1 pt)	4 = 3° (0 pts)
Arthritis tanlonavicular joint	1 = none (4 pts)	2 = 1° (2 pts)	3 = 2° (1 pt)	4 = 3° (0 pts)
Arthritis calcaneocuboid joint	1 = none (1 pt)	2 = yes (0 pts)		

CLFD in 22 (22%). Table 3 indicates the distribution of L according to the Quenu and Küss classification [13]. A total of 86 (85%) of L were closed injuries, and 16 were (16%) open injuries (Figure 2). A total of 10 (10.8%) patients presented isolated L. Associated injuries were predominantly fractures in the lower extremity that were registered in 75% ($n = 70$) of patients (total number of registered fractures: $n = 140$) (Figures 3 and 4). In total, 21 (23%) patients were classified as polytrauma.

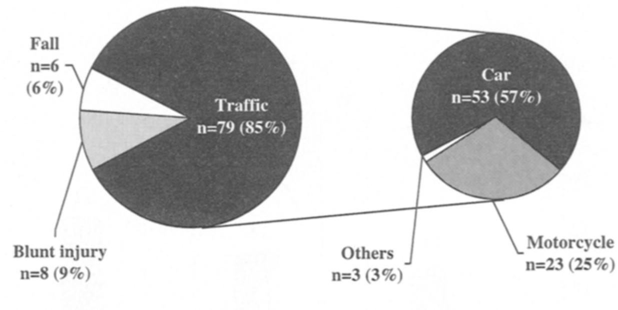

Figure 2
Injury origin in 93 patients with Lisfranc joint dislocations and fracture dislocations.

Treatment

The primary treatment was operative (including semi-operative) in 84% ($n = 85$) of L ($n = 77$ patients; $n = 8$ bilateral L). Closed reduction (semi-operative) was performed in 15 (15%) L and open reduction (operative) in 70 (70%). A total of 85 (84%) received internal fixation including K-wires alone in 50 (50%) cases, K-wires and screws in 25 (25%) and screws alone in five (5%) cases. In 15 (15%) cases, an external fixator was utilized as an adjunct in treatment. Primary arthrodesis of the Lisfranc joint was performed in 10 cases with autologous bone transplant in five of these cases. The indication for primary arthrodesis was a severe or irreconstructable articular damage in LFD or CLFD with an expected high degree of post-traumatic osteoarthritis. Primary below-knee amputation was performed in three (3%) cases with open CLFD in combination with ipsilateral Pilon fractures associated with a polytrauma. In five (5%) cases with LFD, a primary amputation at the Lisfranc joint level was performed. A foot compartment fasciotomy was initially necessary in 34 (34%) of L. In the 70s and 80s, the indication for foot compartment fasciotomy was determined clinically. In the 90s, a specific pressure measurement was performed (Intracompartmental Permanent Pressure Monitoring the TM behind System, Stryker™ Corporation, Santa Clara, CA, USA). The indication for fasciotomy was a difference of less than 30 mmHg between diastolic blood pressure and compartment pressure. A secondary open reduction and internal fixation procedure with K-wires was necessary in two cases at 2 and 6 days with CLFD. Both patients were polytrauma patients who were initially treated with open reduction, internal K-

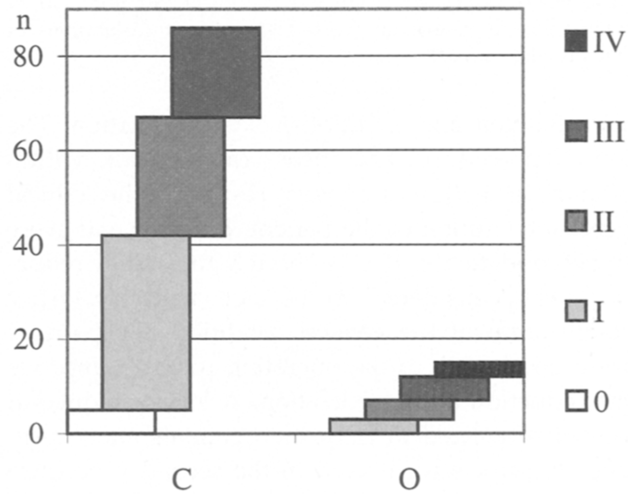

Figure 3
Classification of soft-tissue injury according to Tscherne, showing 101 L (Table 1) [14]. C0–CIII, closed fractures; OI–OIV, open fractures.

Table 3
Injury type and classification. Distribution of 101 Lisfranc dislocations and fracture dislocation in 93 patients according to the Quenu/Küss classification [13]

Injury pattern (n = 93 patients, n = 101 L)	*LD (n = 24)*		*LFD (n = 55)*		*CLFD (n = 22)*	
	n	*%*	*n*	*%*	*n*	*%*
Homolateral%	11	45.8	29	52.7	12	54.5
Isolated	8	33.6	19	34.5	6	27.3
Divergent	5	20.8	7	12.7	4	18.2

LD, pure Lisfranc joint dislocation; LFD, Lisfranc fracture dislocation; CLFD, Chopart–Lisfranc fracture dislocation.

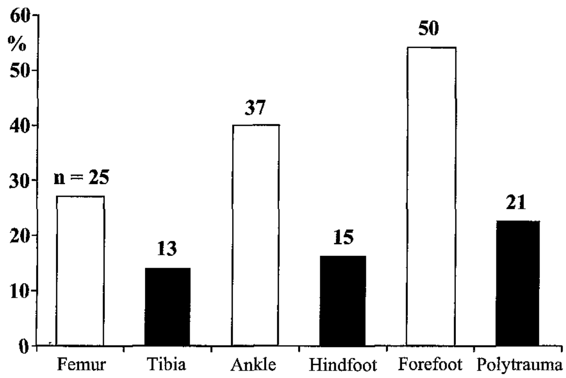

Figure 4
Incidence of associated fractures of the lower extremity and/or polytrauma in 93 patients with Lisfranc joint dislocations or fracture dislocations.

wire fixation and additional external fixation. The initial procedure had been carried out within 30 min in both cases as a result of the critical general condition of the patient. Both patients were transferred to the ICU, although the initial reduction was considered to be not anatomic. After stabilization of the general condition, the patients were taken back to the operating room to improve the reduction and stabilization. A loss of reduction was also realized in those two patients and consequently screws were used in the second procedure instead of K-wires.

A secondary below-knee amputation was performed in three cases because of progressive infection, in one case following an amputation at the Lisfranc level (see above) and in two cases of CDLF without primary amputation. In total, deep infection was observed in four cases, all following open injuries. In total, 40 surgical revision procedures were performed in 35 (38%) patients (secondary skin closure: $n = 36$, debridement and irrigation for infection: $n = 4$).

Postoperative early mobilization with partial weight bearing was allowed in 56 patients ($n = 57$ L, i.e. $n = 1$ bilateral L) cases. Polytrauma patients made up the remaining 21 patients ($n = 28$ L, i.e. $n = 7$ bilateral L) in the study group, which had delayed ambulation. The K-wires and external fixators were removed 6 weeks postoperatively. In total, 16 (16%) patients with isolated unilateral LD were non-operatively treated (cast: $n = 15$, soft dressing: $n = 1$) with temporary partial weight-bearing. One patient with an isolated dislocation of the fifth metatarsal joint was treated with a soft dressing and shoe with a stiff sole. This patient had a history of a deep vein thrombosis (DVT) while wearing a cast on the same leg and denied treatment in a cast.

The mean time between injury and operative treatment was 3.4 ± 5.7 days (range, 0–25 days; median, 0).

Follow-up

A total of 62 (67%) patients ($n = 65$ L, i.e. $n = 3$ bilateral L) had follow-up at an average of 9 years (1.3–25, median 8.5). When considering the group of surviving patients without amputation ($n = 80$), the follow-up rate amounts to 77.5%. Six patients had a follow-up of less than two years. In total, 55 (59%) patients were examined clinically and radiographs were obtained. Clinical examination included rating by scoring systems (AOFAS-Midfoot, HSS, Q) and gait pedobarographic assessment in 15 (16%) patients. Five (5%) patients were assessed by the questionnaire (Q) only.

The mean AOFAS Midfoot Score of the follow-up group was 72 (29–100) points. No significant differences in the scores were found for age at the time of the injury (< 35 years and ≥ 35 years), gender, cause of the injury (motor vehicle accident or other) and method of treatment. The patients with LD or LFD showed no significant differences in this score between groups ($P > 0.05$). Patients with CLFD had significantly lower scores than those without associated Chopart joint fracture dislocation (LD, LFD) ($P < 0.05$). The mean Hannover Scoring System (HSS) score totalled 66 (26–100) points and the Hannover Questionnaire (Q) totalled 64 (30–100) points. Statistical analysis of these two scores (HSS; Q) showed also no statistical differences for age, gender, cause of injury and method of treatment ($P > 0.05$). The group with CLFD showed significantly lower mean scores than LD or LFD in HSS and Q ($P < 0.05$).

The assessment of the radiographs has shown the greatest osteoarthritic changes in patients with CLFD. Correct length of the medial and lateral column and shape of the longitudinal arch correlated with good results in all the scoring systems (Table 4).

The pedobarographic assessment showed normal pressure patterns in the few patients with LD. The

Table 4
Results of the radiographic ($n = 57$) and pedobarographic ($n = 15$) assessment of Lisfranc joint dislocations or fracture dislocations at follow-up

Injury pattern($n = 55$ patients, $n = 57$ L)	*LD* ($n = 15$)	*LFD* ($n = 30$)	*CLFD* ($n = 12$)
Medial column length [17] (correct/incorrect)	11/4	20/10	5/7
Lateral column length [17] (correct/incorrect)	12/3	21/9	4/8
Longitudinal arch shape [18] (excellent, good, fair, poor)	6/3/3/3	7/12/6/5	0/4/4/4
Arthritic changes [19] (absent, doubtful, minimal, moderate, severe)	4/1/5/3/2	6/1/10/8/5	1/0/3/4/4
Pedobarographic assessment ($n = 15$ patients, $n = 15$ L) (normal/near normal/abnormal/severely abnormal)	1/3/1/0 ($n = 5$)	1/2/1/1 ($n = 5$)	0/0/3/2 ($n = 5$)

LD, pure Lisfranc joint dislocation; LFD, Lisfranc fracture dislocation; CLFD, Chopart–Lisfranc fracture dislocation.

patients in the groups LFD or CLFD were characterized by considerable changes in their pressure distribution during the entire stance phase in comparison with the non-injured contralateral extremity and the reported normal pattern (pressure value differences: $P > 0.05$) (Table 4). The pedobarographic measurements correlated with the patients' complaints. Only patients without considerable symptoms showed a normal or near normal gait pattern. The presence of intractable plantar keratosis did not correlate with the results of the pedobarographic measurement. One patient with Lisfranc fracture dislocation had symptoms that were considered to be caused by metatarsalgia and showed an abnormal pressure distribution in the pedobarographic measurement.

Prognostic factors

Table 5 indicates the differences in the AOFAS Midfoot score at follow-up between groups of different ages at the time of the injury, gender, injury cause, injury pattern and classification, type/extent soft tissue damage, time to surgery, type of treatment, method of reduction and internal fixation.

Case reports

Case 1: Isolated homolateral Lisfranc fracture dislocation

A 25-year-old restrained car driver (A.M.) sustained a head-on collision. An isolated, closed, homolateral Lisfranc fracture dislocation of the left foot with associated fracture of the metatarsal bones II and III and the cuneiform bones I and II was diagnosed on the radiographs (Figure 5) and CT scan. After failed closed reduction, an open reduction through a dorsal median incision was performed. Internal fixation was with standard K-wires and an additional 3.5-mm cortical screw between metatarsal I and cuneiform I for greater stability (Figure 6). Then, 5 days postoperatively, mobilization with 15 kg of partial weight-bearing was allowed. The K-wires and screw were removed after 6 weeks. Partial weight bearing was continued for another 6 weeks. The patient returned to work 2 months post injury. At the 9 year follow-up, the patient was functioning well in his profession as a physiotherapist. The radiographs showed near anatomic alignment with minimal osteoarthritic changes in the Lisfranc's joint (Figure 7, grade: minimal [19]). The patient reported no pain and the function was rated as excellent (AOFAS = 92, HSS = 96, Q = 100). No considerable differences in the pressure pattern were observed in comparison with the contralateral side during pedobarography (grade: normal).

Case 2: Homolateral Lisfranc fracture dislocation in a polytrauma patient

A 26-year-old restrained driver (T.S.) struck a tree with the left side of his vehicle. The patient was admitted as a polytrauma with a closed divergent Lisfranc fracture dislocation on the left side involving fractures of the cuboid, cuneiform II and metatarsal II (Figure 8). The patient underwent closed reduction utilizing 4-mm Schantz screws. After failed closed reduction, an open reduction through a dorsal median incision was performed.

Table 5
AOFAS Midfoot score at follow-up in different groups and statistical significance between groups in 55 patients (57 L)

Prognostic parameter	*Mean AOFAS midfoot score*	*Test: significance*
Age at time of injury		
≤ 35 Years	75.1	*t*-test: $P = 0.15$
> 35 Years	68.9	
Gender		
Male	72.5	*t*-test: $P = 0.37$
Female	71.5	
Cause of injury		
MVA	68.3	*t*-test: $P = 0.07$
Non-MVA	75.1	
Injury Pattern		
LD	74.5	ANOVA: $P = 0.03$
LFD	72.3	LD *versus* CLFD: $P = 0.02$
CLFD	61.4	LFD *versus* CLFD: $P = 0.02$
Classification [13]		
Homolateral	70.1	ANOVA: $P = 0.09$
Isolated	76.4	
Divergent	65.4	
Type of soft tissue damage		
Open	61.4	*t*-test: $P = 0.01$
Closed	76.3	
Extent of soft tissue damage [14]		
C0, CI, CII, OI	75.4	*t*-test: $P = 0.01$
CIII, OIII, OIV	60.3	
Associated fractures		
No	75.8	*t*-test: $P = 0.05$
Yes	68.1	
Time to surgery (days)		
0, 1 Day	76.1	*t*-test: $P = 0.02$
> 1 Day	62.4	
Type of treatment		
Operative	70.8	*t*-test: $P = 0.23$
Non-operative	72.8	
Method of reduction		
Open	72.1	*t*-test: $P = 0.34$
Closed	72.3	
Method of internal fixation		
K-wires	70.4	*t*-test: $P = 0.18$
K-wires and screws	75.4	

Internal fixation with K-wires followed (Figure 9). The Schantz screws were then used for external fixation. Then, 2 weeks after surgery, ambulation with partial weight-bearing was begun. The fixator and K-wires were removed 8 weeks postoperatively. Bilateral, full weight-bearing was achieved at 3 months. At the time of follow-up, 9 years after injury, the patient worked in a bank as a cashier. The radiographs showed moderate osteoarthritis with decreased joint space but good anatomical alignment (Figure 10, grade: moderate [19]). The patient reported foot pain only after strenuous activity with no measured loss of motion (AOFAS = 59, HSS = 62, Q = 66). A grossly abnormal pressure pattern during the late stance phase was noted (grade: severely abnormal).

Discussion

The anatomy of the Lisfranc joint is critical in understanding the mechanism of injury and the rationale for appropriate treatment [5]. Isolated dislocations of the medial column in Lisfranc injuries are believed to result from an adduction

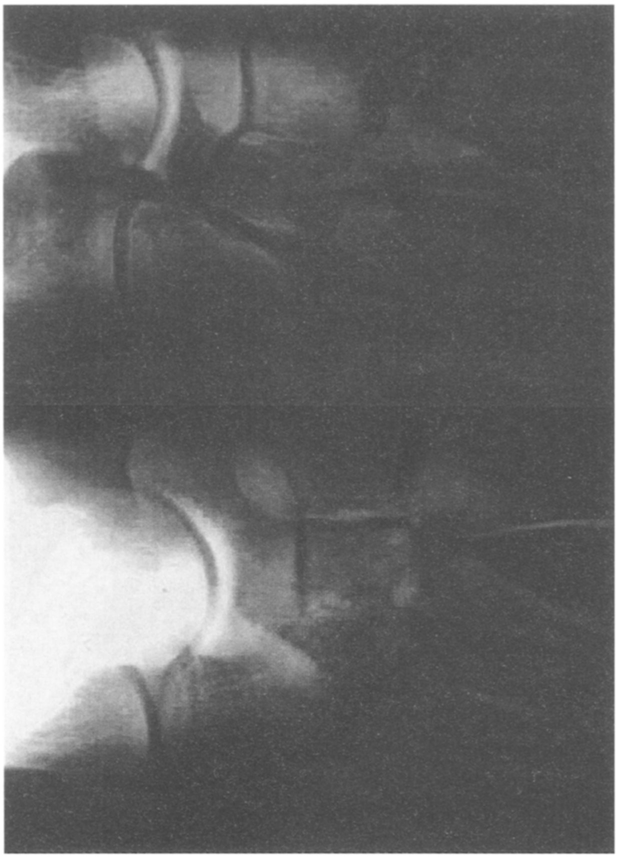

Figure 5
A.M. initial radiographs.

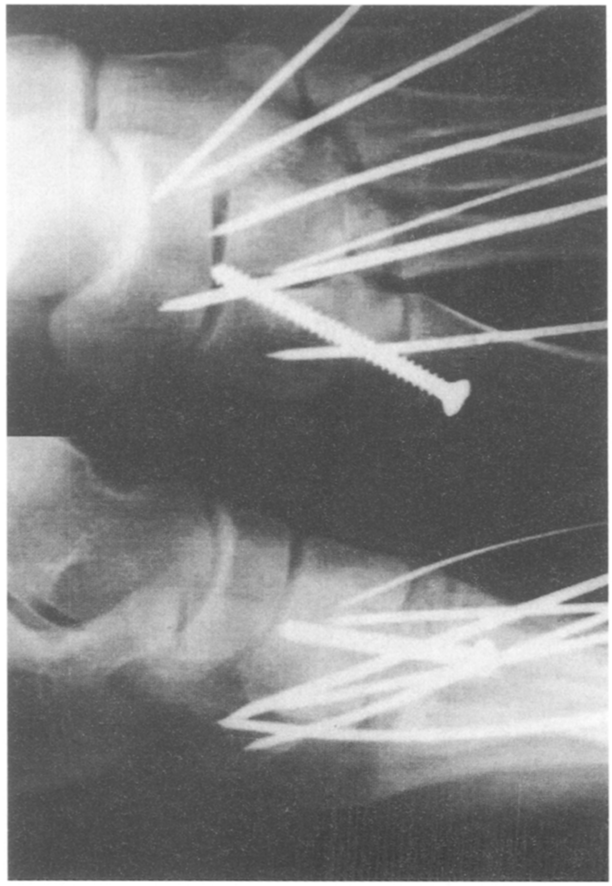

Figure 6
A.M. initial postoperative radiographs.

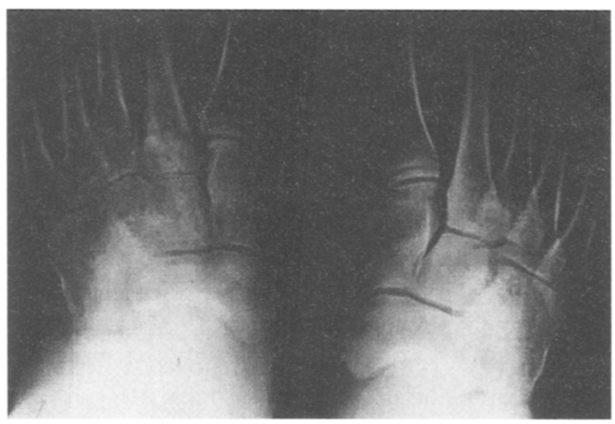

Figure 7
A.M. 9 years postoperative.

force to the forefoot [20,21]. Anatomic reduction is described to be difficult in Lisfranc fracture dislocations and to require usually an open procedure [2,8,22–24]. In the delayed setting, the surgical correction of the length and shape of the longitudinal arch is considered to be important and technically challenging [25]. To describe reduction and fixation techniques, the column theory is found to be useful, with the medial column consisting of the medial cuneiform and first metatarsal, the middle column consisting of the second and third metatarsals and cuneiforms, and the lateral column consisting of the fourth and fifth metatarsals and cuboid [26,27]. The importance of a restoration of the columns is reflected by the high correlation between correct column length and good functional outcome in our study. The treatment should also be dictated by the soft tissue conditions. The arterial anatomy is critical as the anterior tibialis artery has an intermetatarsal branch, which has an anastomosis with the plantar circulation [17]. A rupture of this anastomosis can cause significant haemorrhage and result in a compartment syndrome. Remarkably, the anastomosis was described to be possibly

Figure 8
T.S. initial radiographs.

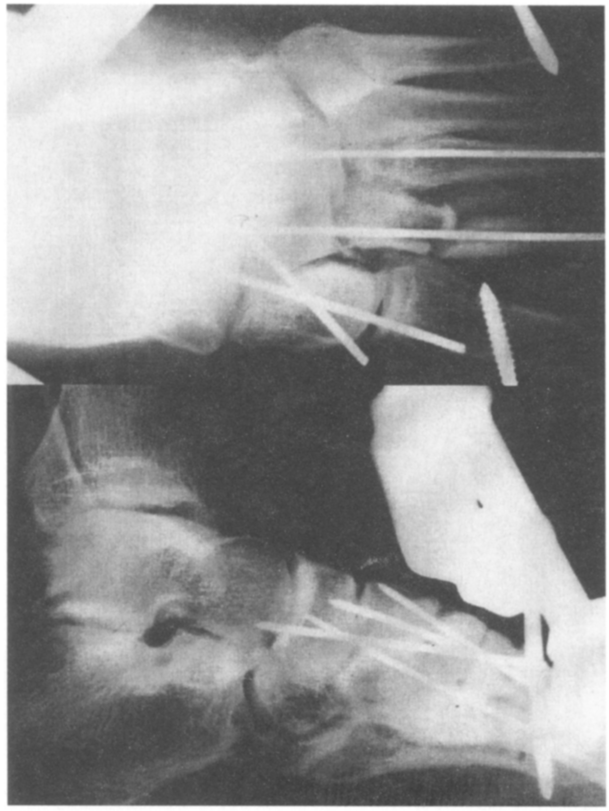

Figure 9
T.S. initial postoperative radiographs.

damaged during reduction manoeuvres when high forces are applied [17].

In our clinical study, we found the same proportion of pure Lisfranc joint dislocations (LD) and fracture dislocation (LFD, CLFD) as described in the literature [6,28–30]. The results of the different scoring systems in our study are similar to other studies [5,27]. For better assessment of the function of the entire foot, we performed a pedobarographic assessment [31]. This evaluation showed the importance of the midfoot in overall foot function. A physiological pressure distribution pattern in the stance phase of the gait was only found in isolated fractures of the midfoot. All complex midfoot fractures resulted in considerable changes in the pressure distribution in comparison with the contralateral uninjured side and a physiological pattern. We could not find significant statistical differences when evaluating age, gender and origin of injury. Significantly lower scores were observed in those patients with Chopart–Lisfranc fracture dislocations (CLFD). The classification of the injuries (Quenu and Küss [13]) was not of significant prognostic value, although divergent dislocations or fracture dislocations resulted in lower AOFAS midfoot scores than homolateral, and especially isolated, dislocations or fracture dislocations. Closed injuries achieved higher AOFAS follow-up scores than open injuries, and injuries with minor to moderate soft tissue damage (Tscherne and Oestern [14]) lead to higher scores than injuries with severe soft tissue damage. Patients with associated fractures showed lower scores than patients without. After surgical treatment, within 24 h after trauma, higher AOFAS midfoot scores were observed than after surgical procedures at a later stage. In the group that sustained their operative procedure at a later stage, the swelling was frequently the indication for a delayed procedure. The soft tissue damage that causes that swelling may influence the outcome more than the delayed operative procedure itself in

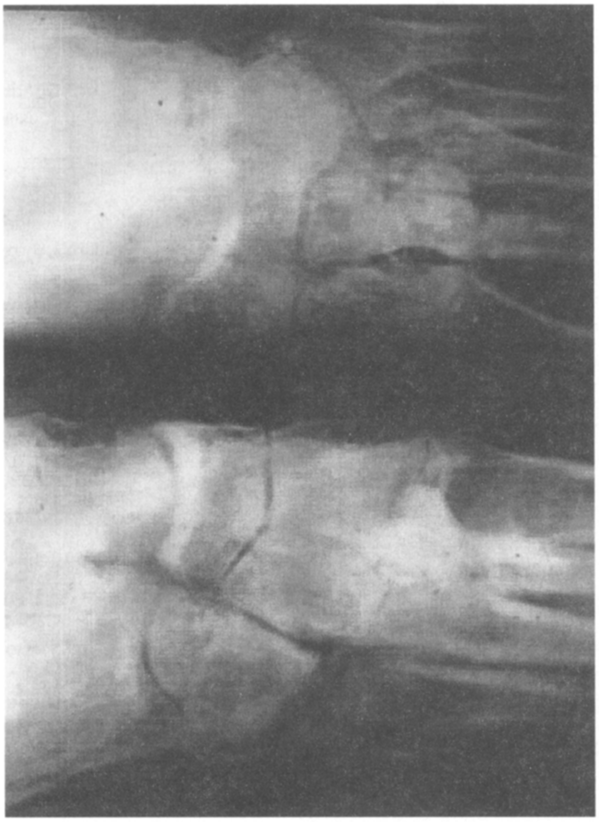

Figure 10
T.S. 8 years postoperative.

this group. Vice versa, patients with compartment syndrome were assigned to the group with operative procedure within the first 24 h, which achieved higher AOFAS scores. Consequently, the effect of the time between injury and operation is unclear. Still, an early operative procedure as initially described in the *Methods* section seems to be reasonable. No statistical significant differences were found in the follow-up scores considering different methods of treatment (operative *versus* non-operative, open *versus* closed reduction, internal fixation with K-wires *versus* K-wires and screws). That does not mean that the treatment has no influence on the outcome in a particular type of fracture, but it means that those differences were not significant within the low case numbers. In conclusion, a severe dislocation fracture, which was treated operatively with open reduction and internal fixation, did not show a significantly worse outcome than an isolated fracture that was treated non-operatively. However, in all fracture dislocations (LFD, CLFD), an initial and maintained anatomic reduction with internal fixation or added external fixation was essential for good results. Although we could not show significant differences in the outcome regarding different methods of internal fixations, we favour screws for stabilization of all rays in open procedures nowadays. No loss of reduction was observed in our series when screws were used. In two cases with K-wires, a loss of reduction occurred and screws were inserted as a second procedure. Stable internal fixation allows further initial partial weight-bearing.

At present, we are more aggressive in the reduction of the complex fracture dislocation injuries. An anatomical reduction is better achieved with an open surgical procedure for all complex Lisfranc injuries. For open reduction, we recommend one or two dorsal incisions. Compartment pressure monitoring should be performed and fasciotomy carried out when indicated. A primary arthrodesis should be considered in injuries with severe joint and/or cartilage destruction. The high rate of associated injuries of the lower extremity or polytraumatized patients results in frequently missed or underestimated Lisfranc injuries. For the initial diagnosis, we recommend conventional radiographic evaluation in three views, i.e. dorsoplantar, lateral and oblique (30° dorsolateral to plantomedial). When the patient's general condition is not critical, a CT scan is highly recommended for evaluation and surgical planning in all complex injuries, i.e. when suspicion for a fracture dislocation exists (CT specifications in our hospital: scan direction, cranio-caudal; slice thickness, 1 mm; rotation time, 1.5 s; voltage, 140 kV; amperage, 43 mA].

Conclusions

Diagnosis and treatment of Lisfranc joint dislocations, and especially Lisfranc joint fracture dislocations, are still problems in trauma care and influence the functional outcome of the entire foot in the mid- and long-term follow-up. In particular, the Chopart–Lisfranc fracture dislocation results in a high degree of residual impairment. But, even in this type of injury, an early anatomic open reduction and optimal internal stabilization were found to improve the final outcome.

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