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Fractures and Fracture Dislocations of the Midfoot: Occurrence, Causes and Long-term Results

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ABSTRACT

Etiology and outcome of 155 patients with midfoot fractures between 1972 and 1997 were analyzed to create a basis for treatment optimization.
Cause of injuries were traffic accidents (72.2%), falls (11.6%), blunt injuries (7.7%) and others (5.8%). Isolated midfoot fractures (I) were found in 55 (35.5%) cases, Lisfranc fracture dislocations (L) in 49 (31.2%), Chopart-Lisfranc fracture dislocations (CL) in 26 (16.8%) and Chopart fracture dislocations (C) in 25 (16%). One hundred and forty eight (95%) of the midfoot fractures were treated operatively; 30 with closed reduction, 115 with open reduction, 3 patients had a primary amputation. Seven (5%) patients were treated non-operatively. Ninety seven (63%) patients had follow-up at an average of 9 (1.3-25, median 8.5) years. The average scores of the entire follow-up group were as follows: AOFAS – sum of all four sections (AOFAS-ET): 296, AOFAS-Midfoot (AOFAS-M): 71, Hannover Scoring System (HSS): 65, and Hannover Questionnaire (Q): 63. Regarding age, gender, cause, time from injury to treatment and method of treatment no score differences were noted (t-test: p>0.05). L, C or I showed similar scores and CL significantly lower scores (AOFAS-ET, AOFAS-M, HSS, Q). The highest scores in all groups were achieved in those fractures treated with early open reduction and operative fixation.
Midfoot fractures, particularly fracture dislocation injuries, effect the function of the entire foot in the long-term outcome. But even in these complex injuries, an early anatomic (open) reduction and stable (internal) fixation can minimize the percentage of long-term impairment.

Key words: Midfoot Fracture

INTRODUCTION

Among the injuries in the foot region, midfoot fractures are still problematic in both diagnosis and treatment and result in a high degree of long-term morbidity.[1,2,10,21,24,31,39] Midfoot fractures are uncommon and predominantly occur in motor vehicle collisions.[5] Despite significant improvements in automobile safety the incidence and severity of midfoot fractures has remained the same.[19,27,28]

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

MATERIAL AND METHODS

The patients treated in the Trauma Department of the Hannover Medical School in Hannover, Germany with midfoot fractures over a 25 year period (1972 and 1997) were evaluated.

The "midfoot" was defined as the region between and including the Chopart and Lisfranc joints. Isolated ligamentous or capsular bone avulsions were not included. In addition to demographic data the origin of the injuries, time from injury to treatment and method of treatment were registered. The outcome was assessed by clinical examination and radiographs for the majority of the patients. Only patients whose treatment was completed at least one 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: 1. Hannover Scoring System (HSS): 2. Hannover Outcome-questionnaire (Q), rating patient's complaints and the functional status based on a severity-symptom scale and functional status,[33] 3. American Foot and Ankle Society (AOFAS) Score.[16] The AOFAS Score was

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recorded for the midfoot (AOFAS-M) and for the entire foot (AOFAS-ET) as the sum of all four score sections (ankle-hindfoot, midfoot, hallux, and lesser toes). The radiographs were evaluated by two orthopaedic surgeons independently (M. R., H. S.). Length of the medial and lateral column (grades: correct or incorrect length), shape of the longitudinal arch (grades: normal or abnormal) and extent of arthritic changes in the midfoot area (grades: none, minimal, moderate, severe) were analyzed and graded. Each case with deviation in any assessment (n=6) were 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, Chi-square and ANOVA 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™ V6.3-4/2000, Novel, Munich, Germany). Pressure value differences were statistically analysed with a t test (significance level: $p<0.05$).

RESULTS

Midfoot fractures in 155 patients were included. In the study group, men (n=114, 73.2%) were affected three times as often as women (n=41, 28.4%). The mean age of the study group was 35 years (10-84) with 12 (7.7%) younger than 18 years. The fractures primarily resulted from traffic injuries (Fig. 1).

Both sides were effected equally (right: n=84, left: n=80), and 9 patients (5.8%) sustained bilateral midfoot fractures. Fracture dislocations of the Chopart and/or Lisfranc joint occurred in two thirds of the cases and midfoot fractures without lesion of those joints in one third (Fig. 2). Associated fractures were found in the lower extremity in 115 patients (74%) (total number of registered fractures: n=245) (Fig. 3).

The primary treatment was operative in 95% (n=148) of patients. Closed reduction was performed in 30 (19.4%) and open reduction in 115 (76.1%). One hundred and sixteen (74.8%) received internal fixation including K-wires alone in 80 (69%) cases, K-wires and screws in 30 (26%) and screws alone in 6 (5%) cases. In 55 (35.5%) cases an external fixator was utilized as an adjunct in treatment. Primary arthrodesis of the Chopart and/or Lisfranc joint was performed in 7 cases and an autologous bone transplant from the ipsileteral iliac crest was used in four of these cases. The indication for primary arthrodesis was a severe or irreconstructable articular damage in Chopart and/or Lisfranc fracture dislocations with an expected high degree of

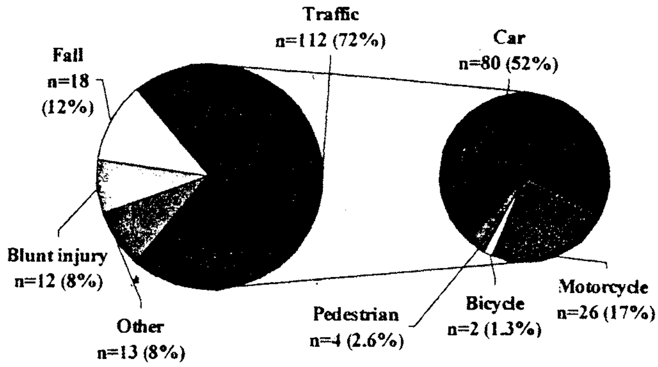

Fig. 1: Injury origin in 155 patients with midfoot fractures

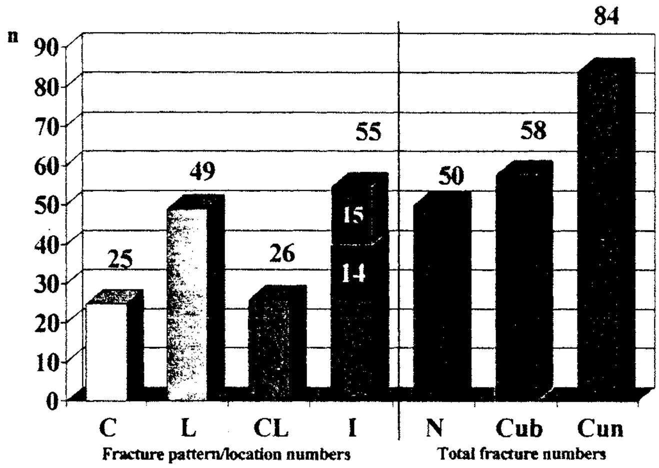

Fig. 2: Location of midfoot fractures (n=155) (C: Chopart fracture dislocation, L: Lisfranc fracture dislocation, CL: Chopart-Lisfranc fracture dislocation, I: midfoot fracture without lesion of the Chopart's and/or Lisfranc's joint, N: Navicular fractures in total, Cub: Cuboid fractures in total, Cun: Cuneiforme fractures in total).

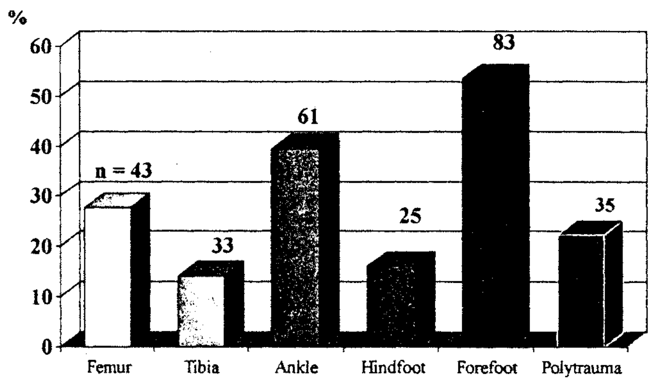

Fig. 3: Incidence of associated fractures of the lower extremity and/or polytrauma in 155 patients with midfoot fractures.

posttraumatic osteoarthritis. Primary below knee amputation was performed in 3 (1.9%) cases with open Chopart-Lisfranc fracture dislocations in combination with ipsilateral Pilon fractures associated with polytrauma. A foot compartment fasciotomy was initially necessary in 18 (11.6%) patients. 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 System, Stryker™ Coporation). The indication for fasciotomy was a difference of less than 30 mm Hg between diastolic blood pressure and compartment pressure. A secondary open reduction and internal fixation procedure with K-wires was necessary in 2 cases at 2 and 6 days with a Chopart fracture dislocation and a Chopart-Lisfranc fracture dislocation. No secondary amputation or arthrodesis was performed. Deep infection was observed in 8 cases all following open injuries. In total, 34 surgical revision procedures were done in 20 (12.9%) patients (secondary skin closure: n=24, debridement and irrigation for infection: n=3, reosteosynthesis: n=5, rearthrodesis: n=2). Postoperative early mobilisation with partial weight bearing was allowed in 120 cases. Polytrauma patients made up the remaining 35 patients in the study group which had delayed ambulation. The K-wires and external fixators were removed 6 weeks postoperatively. Seven (5%) patients with isolated fractures of midfoot bones without associated dislocations of Chopart and/or Lisfranc joint were non-operatively treated (cast: n=3, soft dressing: n=4) with temporary partial weight bearing.

Ninety seven (63%) patients had follow-up at an average of 9 (1.3-25, median 8.5) years. Six patients had a follow-up of less than two years. Seventy-two (54.9%) patients were examined clinically and radiographs obtained. Clinical exam included rating by scoring systems (AOFAS-M, AOFAS-ET, HSS, Q) and gait pedobarographic assessment in 23 (14.8%) patients. Twenty five (19.1%) patients were assessed by the questionnaire (Q) only.

The mean AOFAS Midfoot Score of the follow-up group was 71 (21-100) points. No significant differences in the scores were found for age (<35 years and ≥35 years), gender, cause of the injury (motor vehicle accident or other) and method of treatment (Fig. 4). The

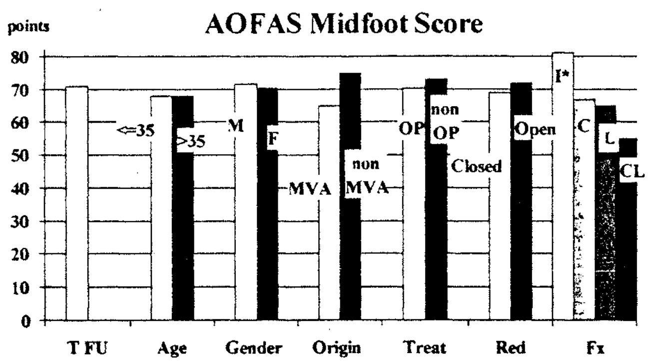

Fig. 4: AOFAS-Midfoot Score of 72 patients with midfoot fractures 16. [Abbreviations: T FU, total follow-up group; Age, age at the time of trauma in years; Gender: M, male, F, female; Origin: MVA, motor vehicle accident, non MVA, other than motor vehicle accident; Treat: OP, operatively, non OP, non operatively; Red: Open, open reduction, Closed, closed reduction; Fx: fracture pattern, I, isolated fracture; C, Chopart fracture dislocation; L, Lisfranc fracture dislocation; CL, Chopart-Lisfranc fracture dislocation; *, t or ANOVA test, p<0.05].

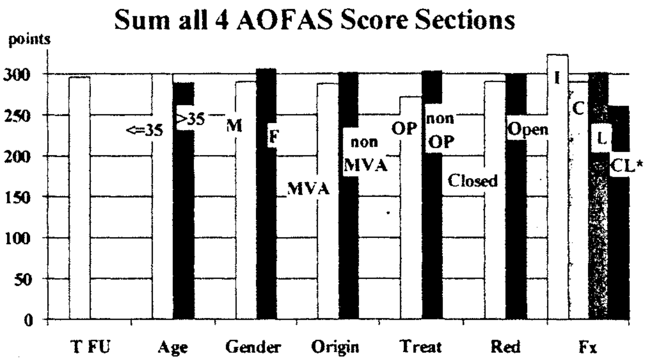

Fig. 5: Sum of all 4 AOFAS score sections of 72 patients with midfoot fractures (Maximum score: 400 points) 16. [Abbreviations: T FU, total follow-up group; Age, age at the time of trauma in years; Gender: M, male, F, female; Origin: MVA, motor vehicle accident, non MVA, other than motor vehicle accident; Treat: OP, operatively, non OP, non operatively; Red: Open, open reduction, Closed, closed reduction; Fx: fracture pattern, I, isolated fracture; C, Chopart fracture dislocation; L, Lisfranc fracture dislocation; CL, Chopart-Lisfranc fracture dislocation; *, t or ANOVA test, p<0.05].

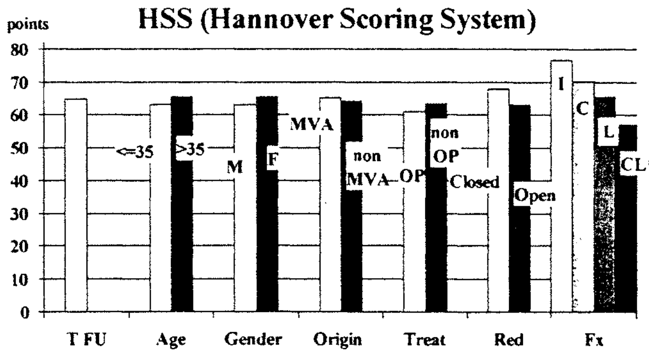

Fig. 6: HSS (Hannover Scoring System) scores of 72 patients with midfoot fractures (Maximum score: 100 points) 33. [Abbreviations: T FU, total follow-up group; Age, age at the time of trauma in years; Gender: M, male, F, female; Origin: MVA, motor vehicle accident, non MVA, other than motor vehicle accident; Treat: OP, operatively, non OP, non operatively; Red: Open, open reduction, Closed, closed reduction; Fx: fracture pattern, I, isolated fracture; C, Chopart fracture dislocation; L, Lisfranc fracture dislocation; CL, Chopart-Lisfranc fracture dislocation; *, t or ANOVA test, p<0.05].

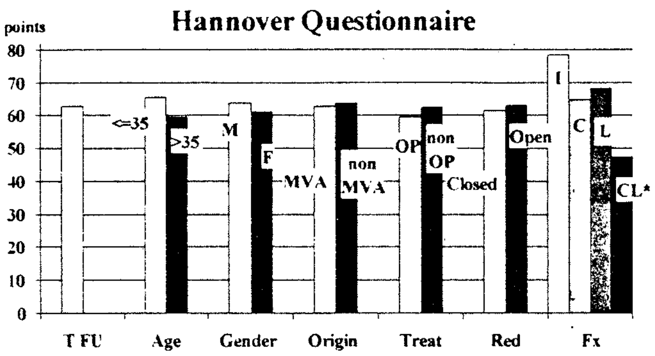

Fig. 7: Q (Hannover Questionnaire) scores of 72 patients with midfoot fractures (Maximum score: 100 points) 33. [Abbreviations: T FU, total follow-up group; Age, age at the time of trauma in years; Gender: M, male, F, female; Origin: MVA, motor vehicle accident, non MVA, other than motor vehicle accident; Treat: OP, operatively, non OP, non operatively; Red: Open, open reduction, Closed, closed reduction; Fx: fracture pattern, I, isolated fracture; C, Chopart fracture dislocation; L, Lisfranc fracture dislocation; CL, Chopart-Lisfranc fracture dislocation; *, t or ANOVA test, p<0.05].

patients with fracture dislocations (C, L, CL) showed no significant differences in this score between groups (p>0.05). Patients with isolated fractures (I) had significantly higher scores than those with fracture dislocations (p<0.05). The mean sum of all four AOFAS score sections (AOFAS-ET) of the follow-up group was 296 (188-398) points (Fig. 5). The mean Hannover Scoring System (HSS) score totalled 65 (23-100) points (Fig. 6) and Hannover Questionnaire (Q) 63 (28-100) points (Fig. 7). Statistical analysis of all three scores ((AOFAS-ET, HSS; Q) showed no statistical differences for age, gender, cause of injury and method of treatment (p>0.05). The group with Chopart-Lisfranc fracture dislocation (CL) showed significantly lower mean scores than the remaining injury types (C, L, I) in AOFAS-ET, HSS and Q (p<0.05).

The assessment of the radiographs has shown the greatest osteoarthritic changes in patients with Chopart-Lisfranc fracture dislocations. Correct length of the medial and lateral column and shape of the longitudinal arch correlated with good results in all the scoring system (Table 1).

The pedobarographic assessment only showed normal or near normal pressure patterns in the patients with isolated midfoot fractures (I). The patients in the groups C, L and CL were in the gross majority characterized by considerable changes in their pressure distribution during the entire stance phase in comparison to the non-injured contralateral extremity and the reported normal pattern (pressure value differences: p>0.05) (Table 1). 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.

DISCUSSION

Midfoot fractures are frequently not diagnosed during primary examination especially when associated with other injuries.[1,3,10,21,30] As a result of inadequate treatment, the complication rate is high.[32,37] Therefore, midfoot fractures have a high rate of mid and long-term morbidity.[5,24,36] Only recognized isolated fractures of the

Table 1: Results of the radiographic and pedobarographic assessment of midfoot fractures (n=155) at follow-up.

Injury pattern (n=72)	I (n=18)	C (n=15)	L (n=25)	CL (n=14)
Medial column length (correct/incorrect)	17/1	11/4	19/6	7/7
Lateral column length (correct/incorrect)	16/2	12/3	20/5	6/8
Longitudinal arch shape (normal/abnormal)	14/4	9/6	19/6	4/10
Arthritic changes (none/minimal/moderate/severe)	12/4/2/0	5/5/3/2	7/10/5/3	1/3/5/5
Pedobarographic assessment (normal/near normal/abnormal/severely abnormal)	4/1/0/0 (n=5)	0/1/2/2 (n=5)	1/2/3/1 (n=7)	0/1/3/2 (n=6)

(C: Chopart fracture dislocation, L: Lisfranc fracture dislocation, CL: Chopart-Lisfranc fracture dislocation, I: midfoot fracture without lesion of the Chopart's and/or Lisfranc's joint).

midfoot have an outcome with minimal functional impairments.[11,13,14,17,25,26,34] In contrast, a fracture dislocation of a single midfoot bone results in a higher morbidity and should affect treatment.[20] The fracture dislocation of the Lisfranc joint is the most frequent severe injury of the midfoot, but is still uncommon with an incidence of 0.02 to 0.9% of all fractures. Jarde et al. estimated that almost 40% of Lisfranc fracture dislocations in polytrauma patients are not recognized.[6,12,15,38] The anatomy of this area is critical in understanding the mechanism of injury and the rationale for appropriate treatment. The second metatarsal is the keystone of the metatarsal arch. It is usually the longest and most rigid and articulates with all three cuneiforms.[39] Isolated dislocations of the medial column in Lisfranc injuries are believed to result from an adduction force to the forefoot.[22,23] Anatomic reduction is difficult in Lisfranc fracture dislocations and usually requires an open procedure.[4,7,8,31,35] In the delayed setting the surgical correction of the length and shape of the longitudinal arch is important and technically challenging.[9] The key to reduction is the second metatarsal which should be aligned at the outset of the procedure since all other metatarsals will not reduce if the second metatarsal complex is not anatomic. For describing reduction and fixation techniques the column theory is 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.[24,39] 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. A rupture of this anastomosis can cause significant hemorrhage and result in a compartment syndrome. Remarkably, the anastomosis can be damaged during reduction maneuvers when high forces are applied.[38]. We try to avoid extensive attempts of closed reduction and favor an open procedure in those cases. An open procedure is furthermore recommended in all open injuries and in all cases with compartment syndrome. 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 3.5 mm cortical screws are used. Normally, all rays are stabilized in a distal-proximal direction perpendicular to the Lisfranc joint surface for optimal stability. When the closed reduction was successful, internal fixation utilizing K-wires or percutaneous screws is used. We recommend the use of a screw for the medial column, i.e. first metatarsal/cuneiform, for greater stability. In open procedures, we favor screws for stabilization of all rays. 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. When mediolateral instability persists an additional screw from medial to lateral through all cuneiforms and the cuboid may be introduced. In cases with associated hindfoot or ankle instability an external fixator between tibia and first and fifth metatarsals is applied. In the majority of cases with an open procedure or an open injury a primary skin closure is not possible and the skin defect is covered with artificial skin. Within one or two weeks a secondary skin closure is normally possible and a skin graft is not necessary. Stable internal fixation allows initial partial weight bearing without a cast. Hardware removal is performed at 6 to 8 weeks, when the joint was not severely injured and painfree joint function can be expected. When a primary arthrodesis is the aim in cases with massive or irreconstructable articular damage the screws will be maintained for one year. Full weight bearing is allowed after 8 to 10 weeks.

The Chopart fracture dislocation is not as common as the Lisfranc fracture dislocation, but is characterised by similar problems.[18,31] Injuries with a combined Chopart- and Lisfranc fracture dislocation are often part of so called "crush" injuries of the foot with gross soft tissue damage and very high rates of deep infection.[10,21,39] These crush injuries lead to the highest impairment of all foot injuries.[24]

In our clinical study we found the same proportion of the isolated (N, Cub, Cun) and combined (C, L, CL) fractures as described in the literature.[1,13,14,21] The results of the different scoring systems in our study are comparable to other studies.[18,39] For better assessment of the function of the entire foot we used the sum of all four AOFAS score sections (ankle-hindfoot, midfoot, hallux, and lesser toes) as a supplementary score,[16] and we performed a pedobarographic assessment.[29] These evaluations showed the importance of the midfoot in overall foot function. An approximate normal gait pattern and excellent or good score results of the other foot areas (ankle-hindfoot, hallux, and lesser toes), were only found in the majority of the patients after isolated midfoot fractures. Complex midfoot fractures and fracture dislocations resulted, in the majority of the patients, in considerable impairment of the foot function

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. Due to the low case numbers, no statistical significant differences were found in the follow-up scores considering different methods of treatment. 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. In conclusion, a severe dislocation fracture that 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, due to the low case numbers in uncommon injuries like midfoot fractures significant score differences could not be demonstrated. However, in all injury pattern groups (I, L, C, CL), an initial and maintained anatomic reduction with internal fixation or added external fixation was essential for good results.

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 midfoot 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 midfoot fractures. 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 is stable, 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 seconds; voltage, 140kV, amperage, 43mA].

CONCLUSION

Diagnosis and treatment of midfoot fractures is still a problem in trauma care and influences the functional outcome of the entire foot in the mid- and long-term follow-up. Particularly 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 was found to improve the final outcome.

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