Primary open reduction and fixation compared with delayed corrective arthrodesis in the treatment of tarsometatarsal (Lisfranc) fracture dislocation

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Fracture-dislocations of the tarsometatarsal (Lisfranc) joints are frequently overlooked or misdiagnosed at initial presentation. This is a comparative cohort study over a period of five years comparing primary open reduction and internal fixation in 22 patients (23 feet) with secondary corrective arthrodesis in 22 patients (22 feet) who presented with painful malunion at a mean of 22 months (1.5 to 45) after injury. In the first group primary treatment by open reduction and internal fixation for eight weeks with Kirschner-wires or screws was undertaken, in the second group treatment was by secondary corrective arthrodesis. There was one deep infection in the first group. In the delayed group there was one complete and one partial nonunion.

In each group 20 patients were available for follow-up at a mean of 36 months (24 to 89) after operation. The mean American Orthopaedic Foot and Ankle Society midfoot score was 81.4 (62 to 100) after primary treatment and 71.8 (35 to 88) after corrective arthrodesis (t-test; p = 0.031).

We conclude that primary treatment by open reduction and internal fixation of tarsometatarsal fracture-dislocations leads to improved functional results, earlier return to work and greater patient satisfaction than secondary corrective arthrodesis, which remains a useful salvage procedure providing significant relief of pain and improvement in function.

Dislocations and fracture-dislocations of the tarsometatarsal (Lisfranc) joints are relatively uncommon with a reported frequency of 0.1% to 0.9% of all fractures.1,2 These estimates are possibly too low, because between 20% and 40% of these injuries are either overlooked or misdiagnosed as foot sprains or isolated fractures of the tarsal and metatarsal bones at first presentation.3-7 If overlooked or not treated correctly tarsometatarsal fracture-dislocations frequently result in painful malunion and impaired function.7-12 A broad spectrum of deformity is seen, depending on the type of primary injury. Most commonly, planus or planovalgus deformities associated with forefoot abduction are seen,13,14 but cavus deformity with forefoot adduction may also be encountered.9,12,15

Several studies have shown that the best predictor of a satisfactory result after tarsometatarsal dislocations is primary anatomical reduction and internal fixation,3,16-19 whereas closed reduction and plaster immobilisation often leads to an unacceptable result and frequent redisplacement.7,16 The methods of operation recommended vary from closed reduction and percutaneous fixation20 to open reduction and internal fixation with Kirschner (K)-wires or screws,5,6,17,20,21 or even primary arthrodesis in cases of severe comminuted fractures,21-24 or ligamentous dislocations.18,25 Calder, Whitehouse and Saxby26 noted significantly inferior results if operative treatment was delayed for more than six months after injury.

Over a period of five years nearly as many patients with painful residual deformity following malunited tarsometatarsal fracture-dislocations presented to our department as were treated for fresh injuries. The aim of this cohort study was to compare the medium-term results of tarsometatarsal fracture-dislocations treated primarily by a standardised protocol of open reduction and internal fixation with those treated by secondary corrective tarsometatarsal arthrodesis for painful malunion during the same period. The preliminary short-term results of this study have been reported previously.27

Patients and Methods

Between October 1993 and October 1998, 22 patients who presented with 23 acute tarsometatarsal fracture-dislocations were treated by primary open reduction and internal...
fixation (group A) (Table I). During the same period, 22 patients presented with residual deformity after tarso-metatarsal dislocation and were treated by secondary corrective tarsometatarsal arthrodesis at a mean of 22 months (1.5 to 45) after the initial injury (group B) (Table I). The shortest time between injury and surgery in group B was six weeks in a patient who had already presented with a fixed deformity at that time. Primary treatment in group B consisted of open reduction and K-wire fixation in three patients, closed reduction and K-wire fixation in four, and closed reduction followed by immobilisation in a plaster cast in seven. In eight of the 22 patients the diagnosis had been missed on first presentation and no specific treatment had been initiated. Conservative measures such as change of footwear, physical therapy, pain medication and walking aids had all failed to relieve symptoms prior to surgery.

Six of the patients in group A and five in group B had multiple injuries at the time of the accident, reflecting the high-energy type of injury often associated with tarso-metatarsal fracture-dislocations. Four patients in each group also had an injury to the mid-tarsal (Chopart) joint. The overall pattern of injury was comparable between the two groups (Table I). Patients with crush injuries to the foot, those with neurological disorders or pre-existing deformity of the foot, and those who did not give their consent, were excluded from the study.

Standard radiographs in anteroposterior (the tubetilted 20° caudally), lateral and oblique (45°) projections were obtained in all patients with acute injuries.28,29 Weight-bearing radiographs of both feet in anteroposterior and lateral projections were obtained prior to secondary corrective arthrodesis7 and at follow-up (Fig. 1).

**Primary open reduction and internal fixation (group A).** Surgery was performed under general or spinal anaesthesia. The medial column of the tarsometatarsal joint was approached by a dorsal longitudinal incision centred over the space between the first and second metatarsocuneiform joints extending from the cuneiform bones to the proximal shaft of the metatarsals. In the presence of an acute compartment syndrome the incision was extended to the distal extensor retinaculum to complete a dorsomedial fasciotomy.30 Reduction was begun at the second metatarsocuneiform joint, which is considered the ‘keystone’ of the tarsometatarsal joints.1,7,31 If there was an additional fracture of the base of the second metatarsal, anatomical reduction and fixation was attempted with 2.0 mm mini-fragment screws. Very small, irreducible fragments were removed. The second metatarsal was then brought into alignment with the intermediate cuneiform and temporarily fixed with a retrograde K-wire. The first and third metatarsals were then reduced and fixed in the same manner. Once reduction of the first to third metatarsocuneiform joints was achieved, the position and stability of the fourth and fifth metatarsals was assessed. If the lateral metatarsals had reduced spontaneously and were clinically stable, no further treatment was undertaken. If the fourth and fifth metatarsals tended to sublux, they were fixed percutaneously with additional K-wires. If percutaneous reduction could not be achieved because of additional fractures or soft-tissue interposition, open reduction and internal fixation to the cuboid was carried out via a second, dorsolateral approach over the fourth intermetatarsal space.

Fixation was achieved with K-wires in 11 feet, with screws in eight and small fragment plates (supplemented by screws or K-wires) in four. In patients with multiple injuries and those with severe soft-tissue damage, K-wire fixation was chosen as the definitive treatment, supplemented by temporary external tibiometatarsal transfixation if there was gross instability or soft-tissue laceration (Fig. 2). If K-wires were used for definitive fixation, they were shortened and buried subcutaneously. If fixation with K-wires appeared inadequate, they were replaced by 2.5 mm to 3.5 mm cortical screws, depending on the size of the bone. The screws were introduced in a retrograde fashion from the base of the metatarsal to the corresponding cuneiform, and countersunk in

**Table I. Patient characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Group A (primary open reduction and temporary internal fixation)</th>
<th>Group B (secondary corrective arthrodesis)</th>
</tr>
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<tbody>
<tr>
<td>Number of patients (feet)</td>
<td>22 (23)</td>
<td>22 (22)</td>
</tr>
<tr>
<td>Male:female</td>
<td>17:5</td>
<td>15:7</td>
</tr>
<tr>
<td>Mean age at time of injury (range)</td>
<td>35 (17 to 76)</td>
<td>39 (24 to 60)</td>
</tr>
<tr>
<td>Fracture classification (Quénu and Küss)35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homolateral</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Isolated</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Divergent</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Polytroama/multiple injuries</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Mean time to surgery in months (range)</td>
<td>0</td>
<td>22 (1.5 to 45)</td>
</tr>
<tr>
<td>Time to follow-up in 20 available patients in each group in months (range)</td>
<td>37 (24 to 89)</td>
<td>35 (26 to 47)</td>
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order not to irritate the extensor tendons. Realignment of the tarsometatarsal joints was assessed with intra-operative lateral, oblique and dorsoplantar radiographs.

A short-leg cast was applied post-operatively for seven to ten days. External fixation was used until soft-tissue swelling had subsided, usually for less than 14 days. After screw or plate fixation patients were mobilised in their own shoes with a hard sole. After K-wire fixation a cast shoe was applied for six weeks. All patients were restricted to partial weight-bearing (20 kg) for eight weeks. The hardware was removed after that time and weight-bearing was gradually increased over the following two weeks.

**Secondary corrective arthrodesis (group B).** In patients with residual deformity the extent of the arthrodesis depended on the number of affected joints and the degree of deformity. One or two parallel longitudinal dorsal incisions were made over the first and fourth web spaces. All fibrous and scar tissue, remaining cartilage, subchondral and non-viable bone was removed from the joints. Where there was substantial deformity or structural bone loss the defect was filled with a tricortical bone graft from the ipsilateral iliac crest, and occasionally with local osteophytes. Axial malalignment and forefoot abduction/adduction were corrected, starting with the first or second metatarsocuneiform joint. If realignment was satisfactory as judged by intra-operative fluoroscopy, the medial column was fused with compression screws, including the inter-cuneiform and naviculocuneiform joints if necessary. In 14 of 22 feet the fourth and fifth metatarsals could be reduced into the anatomical position once realignment of the medial column had been achieved (Fig. 3). They were fused to the cuboid in the remaining eight feet when there was severe damage to the fourth and fifth tarsometatarsal joints. Final radiographs were taken in the three standard projections described previously.

A short-leg cast was applied post-operatively for seven to ten days and then replaced by a cast shoe that was worn for eight weeks. Full weight-bearing was allowed within the cast shoe except in patients with poor bone quality or after bone grafting. These patients were restricted to partial weight-bearing (20 kg) for eight weeks.

**Follow-up.** Patients were followed by a clinical examination and gait function tests, such as toe- and heel-gait, squatting, jumping etc. The Maryland foot score\textsuperscript{16,32} and American Orthopaedic Foot and Ankle Society (AOFAS) midfoot score\textsuperscript{33} were used to quantify the functional outcome. Both include several objective and subjective criteria. Patients filled in a questionnaire on their level of activity, satisfaction with treatment and activities of daily living (ADL). Lateral and dorsoplantar weight-bearing radiographs as well as 45° oblique views of the foot were taken.

The following radiological measurements were used for evaluation: the talus-first metatarsal angle (dotted line, measured in lateral and anteroposterior weight-bearing radiographs; the latter with 20° caudally tilted tube), distance between first and second metatarsal base (MT 1-2 distance (mm), arrows in the anteroposterior view), and distance between plantar aspect of the fifth metatarsal base and the cuboid (Cuboid-MT 5 distance (mm), double-arrow in the lateral view).

![Fig. 1a](image1)  ![Fig. 1b](image2)

Radiographs showing characteristics used for follow-up: TFMA, talus first metatarsal angle (dotted line, measured in lateral and anteroposterior weight-bearing radiographs; the latter with 20° caudally tilted tube), distance between first and second metatarsal base (MT 1-2 distance (mm), arrows in the anteroposterior view), and distance between plantar aspect of the fifth metatarsal base and the cuboid (Cuboid-MT 5 distance (mm), double-arrow in the lateral view).

\textsuperscript{28,34} Differences in outcome between the two groups were evaluated with a two-sample Student’s $t$-test after testing the groups for normality. Statistical significance was assumed at $p < 0.05$. 
Results

Complications. In group A (22 patients, 23 feet) there was one soft-tissue infection and one superficial wound edge necrosis. Two patients developed a compartment syndrome of the foot which required fasciotomy within 24 hours of injury. One patient had a sensory deficit of the dorsum of the midfoot after fasciotomy for compartment syndrome, indicating a lesion of the superficial peroneal nerve. No haematomas and no vascular injuries were seen. All fractures healed uneventfully with no sign of delayed or non-
union. No implant failure was seen during the eight weeks of temporary fixation.

In group B (22 feet) there was one partial and one complete nonunion. The patient with the complete nonunion had a soft-tissue infection after initial treatment with incomplete open reduction and K-wire fixation. This patient was not satisfied with the result of the arthrodesis, but declined further surgery. Another patient developed an isolated nonunion of the first metatarsocuneiform joint. However, he was satisfied with the result and declined further surgery. His overall functional result was fair. In one foot a haematoma of the midfoot required decompression on the second post-operative day, but the wound healed uneventfully. No superficial or deep infection and no wound necrosis were seen in this group. Implant failure of one or two screws was observed in four of 22 patients, one in the patient with complete nonunion. Implant failure was asymptomatic in the other three patients who had a solid union on the radiographs and no further treatment was undertaken.

**Clinical results.** In each group, 20 patients were followed up for a mean of three years (two to 7.4) post-operatively. The main clinical and radiographic findings are summarised in Table II. Subjectively, in group A all but one patient were satisfied with the result. In group B, two patients, among them one with complete nonunion, were not satisfied. Considering the severe functional limitation before secondary corrective arthrodesis, all but one of the 20 stated that, given the same circumstances, they would undergo surgery again.

The mean Maryland foot score was 85.0 in group A compared with 76.2 in group B ($t$-test; $p = 0.027$). In group B the mean value before arthrodesis was 37.2 (18 to 66), indicating a significant functional improvement after surgery ($t$-test; $p = 0.001$). The mean AOFAS midfoot score was 81.4 in group A compared with 71.8 in group B ($t$-test; $p = 0.031$). Again, there was a substantial improvement in the scores in the latter group, compared with the mean value before surgery, which was 17.9 (0 to 55). The difference was highly significant ($t$-test; $p = 0.001$). Subjectively, the patients rated their functional results as excellent in
The treatment outcomes were rated excellent in three, good in nine, fair in six, and poor in two. In group B, given the numbers available, we found no difference in outcome between 13 patients treated by fusion of the medial column only and seven patients with fusion of all the tarsometatarsal joints.

**Radiographic results.** The measurements of the talus-first metatarsal angle in the anteroposterior and lateral weight-bearing radiographs, the distance between the base of the first and second metatarsals in the anteroposterior weight-bearing radiographs, and the distance between the base of the fifth metatarsal and the cuboid in the lateral weight-bearing radiographs were close to the normal values for both groups (Table II). With the numbers available, no statistically significant differences between the two groups were seen for any of these observations.

**Discussion**

The assessment and management of tarsometatarsal fracture-dislocations has changed considerably since the first systematic studies by Quénu and Küss almost 100 years ago, although their classification is still in use today with some modifications. Treatment has changed from closed reduction with or without K-wire fixation to open reduction and internal fixation with either K-wires or screws.

Fractures and dislocations of the tarsometatarsal (Lisfranc) joint are frequently overlooked or misdiagnosed. In our experience this is because of the low incidence of these injuries, the variation in the pattern of injury and clinical presentation. There is a lack of knowledge of the specific clinical signs and radiological projections such as the plantar ecchymosis sign, linked toe dislocation and the fleck sign at the base of the second metatarsal. Furthermore, tarsometatarsal injuries are often seen in patients with multiple injuries. The importance of careful physical and radiological examination of these patients cannot be overestimated. As a result, over a period of five years, nearly as many patients presented to our department with painful residual deformities after malunion of tarsometatarsal fracture-dislocations as were treated during the same period for acute injuries to the tarsometatarsal joint. In more than one-third of the patients in group B the diagnosis of tarsometatarsal dislocation had been missed completely at the initial examination. This observation led us to prospectively follow-up the patients from both groups with a standard protocol and to compare the final outcome at a minimum of two years.

The patients who presented with painful arthritis and residual deformity after tarsometatarsal fracture-dislocation had been treated initially with open reduction and K-wire fixation in only three of the 22 cases. Closed reduction was attempted and followed by K-wire fixation or open reduction and internal fixation with either K-wires or screws.

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Whether to use K-wires or screws for internal fixation is controversial. Although some authors prefer K-wire fixation, others opt for screw fixation after open reduction of tarsometatarsal fracture-dislocations. Although a few reports show a slightly higher failure rate after K-wire fixation, there is no clear evidence from these studies on the superiority of either method of treatment. We observed failure of previous K-wire fixation in three patients who presented for correction and therefore we gradually shifted from K-wire to screw fixation for primary treatment. However, we have shown no difference in outcome between the patients treated with K-wires and screws, and no loss of correction after K-wire fixation. We prefer K-wires in patients with multiple injuries, in cases where the condition of the soft tissues is critical and when comminuted fractures of the metatarsal bases do not allow adequate purchase for a screw.

There is no clear evidence on how long to maintain fixation after primary open reduction. K-wires are usually removed after eight weeks but screws are left in place for three to 36 months. Some advocate their removal only in symptomatic patients. In our practice K-wires and screws are removed eight weeks after surgery, and then weight-bearing is increased gradually over the following two weeks. With this regimen no secondary displacement was observed in this study. We believe that eight weeks of fixation is sufficient to maintain reduction.

Secondary corrective arthrodesis resulted in a significant reduction of pain and an improvement in function after initially overlooked or misdiagnosed tarsometatarsal fracture-dislocations, which is in accordance with recent studies. However, in the 20 of 22 patients in each group in this study followed up at a mean of three years after treatment, primary open reduction and internal fixation gave significantly better functional results and an earlier return to work than secondary corrective arthrodesis. Because anatomical reconstruction, as judged by the radiological parameters, could be achieved in both treatment groups, the difference in the results must be attributed to other factors. Long-standing deformity and soft-tissue contracture require extensive surgical exposure and sometimes bone grafting, which may cause a greater amount of scarring in the secondary arthrodesis group. Fusion of the tarsometatarsal joint results in increased stiffness of the midfoot, whereas K-wires and screws were removed after eight weeks in the primary treatment group. This may lead to residual pain and functional impairment, such as difficulty in walking over uneven ground and alterations in footwear. This may be reflected by the scores shown in the subcategories in Table II. The main differences between the two groups were in the pain and function scores, with no significant differences in alignment and aspect.

It has been suggested that results after fusion of the whole tarsometatarsal joint are inferior to those after fusion of the first to third metatarsocuneiform joints only because of the remaining mobility in the fourth and fifth metatarsocuboid joints. In the author’s practice fusion was limited to the medial column in the majority of cases (Fig. 2). However, in the present study no difference in outcome was seen between patients with fusion of the medial column and those with fusion of the whole tarsometatarsal joint.

The high satisfaction rate in 18 of the 20 patients in the secondary arthrodesis group despite inferior functional results may be attributed to the relief of pain and significant functional improvement compared to the pre-operative state. Patients treated by secondary arthrodesis had an average period of 22 months (1.5 to 45) with pain and poor function of the foot, during which the majority were unable to work. The experience of a painful disability and the resulting socioeconomic costs should not be underestimated in these patients. Therefore, a wait-and-see attitude should not be adopted when dealing with these injuries. Some earlier authors have concluded even gross deformity after primary conservative treatment of tarsometatarsal fracture-dislocations did not lead to functional impairment and residual pain, and thus secondary arthrodesis was not required. The results of this study and the observations of other authors that anatomical reduction is the most important predictor of good or excellent results after tarsometatarsal fracture-dislocations contradict these earlier studies.

Conclusions
Primary treatment of tarsometatarsal (Lisfranc) fracture-dislocations with open reduction and internal fixation leads to significant better functional results than does secondary corrective arthrodesis for malunited fracture-dislocations. Care should be taken to not overlook the sometimes subtle clinical and radiographic signs of these injuries, as residual deformities can lead to severe functional impairment. A high index of suspicion is required in patients with multiple injuries, who make up a considerable part of the patient cohort with tarsometatarsal injuries. Closed reduction of complex tarsometatarsal dislocations is not encouraged, because anatomical reduction is an important predictor of outcome. In cases of painful malunion, secondary corrective arthrodesis provides significant relief of pain and improvement in function.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References