Lisfranc Arthrodesis for Chronic Pain: A Cannulated Screw Technique

Nine patients with injury to the tarsometatarsal joint underwent fusion with cannulated screw fixation after conservative treatment had failed. Symptoms consisted of localized pain, forefoot abduction, and progressive collapse of the medial column. Early diagnosis and treatment were associated with a better functional outcome. The technique involved either a single or double incisional approach, resection of joints, reduction and fixation with cannulated cancellous screws. A total of 43 joints were fused: 37 tarsometatarsal joints and 6 tarsal joints. A partial Lisfranc joint complex fusion (medial three joints) was performed in four patients and a total joint complex fusion was performed in five patients. Intertarsal fusion was performed when pathologic change was evident. A cannulated screw was used to fixate 40 of the 43 joints fused. Reduction was performed prior to arthrodesis, when significant fracture-dislocation had occurred. The cannulated self-tapping cancellous screw technique provides a method of reduction that decreases technical difficulty while providing compression across the fusion site. After an average follow-up of 29 months (range 20 to 36 months), seven patients (78%) rated their outcome as good. One patient had a fair result (11%), and one patient had a poor result (11%).

Key words: Lisfranc, arthrodesis, tarsometatarsal, cannulated screw

Joseph R. Treadwell, DPM, FACFAS1,2
Mitchell D. Kahn, DPM, FACFAS1

Injury to the tarsometatarsal joint can lead to chronic pain, deformity, and prolonged disability (1,2). Delayed treatment after initial injury demonstrates a negative correlation with desired outcome (3). Anatomic reduction does not guarantee an uncomplicated course; it does, however, improve functional results. Severe disruption may initially present with only subtle radiographic changes (4). Neither injury type nor radiographic findings are predictive for post-traumatic arthrosis (5,6). Fracture-dislocation of the Lisfranc joint is considered rare (7,8). The diagnostic frequency of this injury increases as a more thorough understanding of the anatomic integrity occurs (9).

Arthrodesis is the recommended treatment when symptoms are not alleviated after an acceptable period of conservative care (2,5,6,8,9). The goal of fusion is to alleviate pain, and create a foot structure that will restore the patient's normal functional capabilities. Additional tarsal surgery is indicated when pathology is present.

Materials and Methods

All patients sustained traumatic injuries that resulted in disruption of the Lisfranc joint complex. No patient was a polytrauma victim. All injuries were isolated to the affected lower extremity. Prior treatment for three patients included open reduction with Kirschner-wire fixation, open reduction with screw fixation, and open reduction with external fixation. Casting, physical therapy, and bracing were the treatment for three patients; and three patients with unrecognized injury were treated elsewhere with physical therapy and observation. Preoperative symptoms included localized pain in all patients, progressive collapse of the medial column with forefoot abduction in seven patients, and posterior tibial tendon pathology in two patients. Four patients had degenerative intertarsal changes, and one patient had a fracture-dislocation of the medial navicular cuneiform joint. There were four males and five females in the study. Six left feet and three right feet were involved. The average patient age was 39 years (range 23 to 53).

Weightbearing radiographs were taken preoperatively and postoperatively after consolidation. Nonweightbearing radiographs were taken immediately postoperatively and every 3 weeks until consolidation. If consolidation occurred in the 7th or 8th week, it was recorded as 9 weeks for fusion because of the interval of visits. All patients were fitted for semi-rigid orthoses, which were worn for a minimum of 6 months after initiation of full...
weightbearing. The authors have found that patients who underwent Lisfranc fusion demonstrated less symptomatology within the arch and midfoot when added support was provided.

Reduction was aimed at maintaining normal talometatarsal, metatarsus adductus, and metatarsal declination angles, as well as a normal metatarsal parabola. Maintenance of the metatarsal heads on the same transverse plane was attempted. Weightbearing radiographs of the contralateral side were used as reference templates for reduction. Normal metatarsal alignment to their respective tarsal bones was the aim. Intra-operative fluoroscopy was used for reduction evaluation in all cases. Guide wires were directed proximal plantarly into the tarsal bones from their respective dorsal metatarsal bases. The 4.0 cannulated cancellous screws were inserted over the guide wires after reduction was achieved.

Results were graded as good, fair, and poor. A good result implied no pain at any time including during vigorous activity. (Vigorous activity included walking for exercise, running, dancing, or any form of impact exercise.) A fair result indicated pain with vigorous activity or pain that required modification of normal daily activities. A poor result implied marked pain with weightbearing, unrelieved by modification of activities; need for revisional surgery; or symptomatic nonunion.

Technique

The procedure was performed under local anesthesia with patients in the supine position with an ankle tourniquet. For those requiring tendon repair, spinal or general anesthesia with a thigh tourniquet was used. An incision of approximately 9 cm. positioned over the medial aspect of the second tarsometatarsal joint (Fig. 1) allowed access to the medial joint complex (medial three tarsometatarsal joints). An incision of approximately 6 cm., made over the lateral edge of the base of the fourth metatarsal (Fig. 2), allowed access to the lateral joint complex (4th and 5th tarsometatarsal joints). Care was taken upon dissection to identify the medial neurovascular bundle. With the medial incision placement, the neurovascular bundle was left virtually undisturbed throughout the procedure, inasmuch as it did not interfere with bone resection from the tarsometatarsal joints. The neurovascular bundle was easily mobilized for intercuneiform fusion. Angular deformities were corrected by appropriate resections of the metatarsal bases. Characteristically the forefoot abducts and dorsiflexes in long-standing deformities. Wedges with their bases medial and plantar were typically removed from the metatarsal bases, with a goal of minimum bone resection. Excessive bone resection reduces the width of the metatarsal base, possibly precluding the use of screw fixation. Screws were inserted starting from the first metatarsal and proceeding laterally. Reduction was considered to be achieved when the talometatarsal angle and metatarsus adductus angle were within normal limits, the metatarsal bases were aligned with their respective tarsal bones, and the metatarsal parabola was normal as viewed on a dorsoplantar image (Fig. 3). From the lateral view, the metatarsal declination angle and the talometatarsal angle were aligned to be within normal limits (Fig. 4). Attempts were made to maintain the metatarsal heads on the same transverse plane when the heel bisection was vertical. If the patient had an unusual foot type or structure, attempts were made to reduce the foot to a position similar to the contralateral side if it was asymptomatic. After bone resection, the tarsometatarsal joints were stabilized with 1.25 mm. guide wires for 4.0 mm. cannulated self-tapping cancellous screws (Fig. 5). The first tarsometatarsal joint was fixated with two screws, and the other joints were fixated with one.
A partial Lisfranc complex fusion (medial three joints) was performed on four patients; a total joint complex fusion was performed on five patients. Intertarsal fusion was performed on four patients. The primary intertarsal fusion entailed a 4.0 mm cannulated cancellous screw directed laterally into the middle cuneiform from the medial cuneiform (Fig. 6). Pain location and severity of deformity determined whether a partial or complete joint complex fusion was performed. Intraoperative fluoroscopy was used in all cases to evaluate reduction and fixation (Fig. 7A, 7B).

All patients were placed in a posterior splint with compressive dressing postsurgically. At 2 to 3 weeks the splint was removed. Sutures were removed at the time of splint removal, and a below-the-knee cast was applied. Ideally patients were nonweightbearing for the first 6 weeks or until fusion was radiographically evident. Weightbearing in a walking cast was begun only after radiographic evidence of consolidation across the fusion sites, with the exception of one patient who was partial weightbearing through recovery. This patient had cerebral palsy and was unable to use crutches.

The screw heads were countersunk, and a small groove, created with a power bur, was placed on the dorsal aspect of the metatarsal bases approximately 1.5 to 2 cm. from the tarsometatarsal joint. Screws were inserted at the distal end of the groove to avoid fracturing the dorsal cortex.
Primary intertarsal fusion is between the medial and intermediate cuneiform with a laterally directed screw. Absorbable screws fixated the second and third tarsometatarsal joints in this patient.

Results

Pain was the primary indication for surgery in all patients with Lisfranc arthrosis. Associated pathology included attenuated and hypertrophic posterior tibial tendon tears (confirmed by magnetic resonance imaging), tarsal fracture, lateral impingement syndrome, transverse fracture nonunion of a second metatarsal base, and a metatarsal neck fracture. In addition to the Lisfranc fusion, two patients had posterior tibial tendon repairs, one patient had a medial column fusion, and four patients had intertarsal fusions. The mechanism of injury was a fall from a height in four patients, industrial related crush injury in three patients, a motor vehicle accident in one patient, and an inversion injury in one patient.

A total of 37 tarsometatarsal joints were fused, 36 by lag screw technique, and 34 by 4.0 mm. cannulated cancellous self-tapping partially threaded screws (Table 1). Two joints were fused by 3.5 mm. absorbable partially threaded cancellous screws. One joint was fused by modified tension band technique because of dorsal cortical fracture of a fifth metatarsal base at the time of surgery (Fig. 8). Four patients had a total fusion of six intertarsal joints. A partial joint complex fusion was performed in four patients, and a total joint complex fusion was performed in five patients. Autogenous bone grafts and allogenic implants were not used.

Follow-up ranged from 20 to 36 months, with an average follow-up of 29 months. An average of 26
TABLE 1 Cannulated screw arthrodesis of the Lisfranc joint

<table>
<thead>
<tr>
<th>Patient n.</th>
<th>Age (yrs.)</th>
<th>Mechanism of Injury</th>
<th>Time From Injury to Salvage (mo.)</th>
<th>TM Joints Fused</th>
<th>Tarsal Joints Fused</th>
<th>Time to Fusion (wk.)</th>
<th>Result</th>
<th>Follow-up (mo.)</th>
<th>Fusion Failure (# of Joints)</th>
<th>Complications</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>23</td>
<td>Fall</td>
<td>18</td>
<td>5</td>
<td>0</td>
<td>12</td>
<td>Fair</td>
<td>20</td>
<td>1</td>
<td>Nonunion</td>
<td>diastasis</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>Crush</td>
<td>32</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>Good</td>
<td>24</td>
<td>0</td>
<td>Had cerebral palsy</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>38</td>
<td>MVA</td>
<td>25</td>
<td>3</td>
<td>1</td>
<td>6</td>
<td>Good</td>
<td>32</td>
<td>0</td>
<td>Had initial ORIF</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>43</td>
<td>Fall</td>
<td>20</td>
<td>5</td>
<td>0</td>
<td>6</td>
<td>Good</td>
<td>34</td>
<td>0</td>
<td>Had initial ORIF</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>44</td>
<td>Twist</td>
<td>34</td>
<td>5</td>
<td>1</td>
<td>6</td>
<td>Good</td>
<td>30</td>
<td>0</td>
<td>Had initial ORIF</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>33</td>
<td>Crush</td>
<td>37</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>Good</td>
<td>32</td>
<td>0</td>
<td>Metatarsalgia</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>37</td>
<td>Crush</td>
<td>19</td>
<td>5</td>
<td>1</td>
<td>9</td>
<td>Poor</td>
<td>28</td>
<td>0</td>
<td>Second surgery</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>Fall</td>
<td>35</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>Good</td>
<td>24</td>
<td>0</td>
<td>Had initial ORIF</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>53</td>
<td>Fall</td>
<td>14</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>Good</td>
<td>36</td>
<td>0</td>
<td>Had initial ORIF</td>
<td></td>
</tr>
<tr>
<td>Avg.</td>
<td>39</td>
<td></td>
<td>26</td>
<td>8</td>
<td></td>
<td>8</td>
<td></td>
<td></td>
<td>29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TM = Tarsometatarsal, MVA = Motor vehicle accident, ORIF = Open reduction.

FIGURE 8 Total joint complex fusion with tension band technique in fifth tarsometatarsal joint because of intra-operative complication. Countersinking of proximal edge of drill hole may prevent cortical fracture.

months (range 14 to 37 months) elapsed from the time of initial injury to the time of salvage arthrodesis. Weightbearing was initiated at 6 weeks in four patients, 9 weeks in four patients, and one patient with cerebral palsy was partial weightbearing with a walker for 12 weeks. Radiographic union occurred at an average of 8 weeks (range 6 to 12 weeks). One patient developed an asymptomatic nonunion of the first tarsometatarsal joint. Good results were obtained in seven patients (78%). One patient had a fair result (11%), and one patient had a poor result (11%). The patient with the poor result required elevating osteotomies of the second and third metatarsals and resection of a prominent fifth metatarsal base plantarly after a total joint complex fusion (Fig. 9). This patient went on to become asymptomatic. The patient with the fair result had cerebral palsy, developed one asymptomatic nonunion of the first tarsometatarsal joint with an attempted total joint complex fusion, and developed a diastasis between the first and second rays 6 months postsurgically (Fig. 10). No intertarsal fusion had been performed. This patient was partial weightbearing during recovery. The patient’s daily activities and shoe gear were modified because of pain during certain activities, and no further surgery was required.

Fusion of the lateral rays was performed only if pain or severe deformity with degenerative changes were present. Patients who had only the medial joint complex fused did not develop pain in the lateral joint complex. There was no correlation between the number of joints fused and the functional outcome. The fourth and fifth joints were never fused independently of each other.

No skin or wound complications occurred. The length of the incisions allowed for gentle retraction, and skin slough from multiple incisions was negated by having a maximum of only two incisions. Nerve injury was avoided by having a better subcutaneous orientation created by the position and length of the medial incision.

In subtle injuries of the Lisfranc joint, a shorter lapse of time from diagnosis to treatment correlated with a lesser degree of deformity. Anatomic reduction correlated with a better functional outcome. The age of the patient and number of joints fused did not affect outcome. At the time of surgery, in several patients, there was evidence of previous fracture on the dorsal surfaces of the metatarsals and cuneiforms at the joint level that was not evident on radiographs. One patient had a healed fracture of the fourth metatarsal neck at the time of arthrodesis, and another had a symptomatic fracture nonunion of the second metatarsal base. One patient had a navicular fracture at the time of the initial injury and went on to have a medial column fusion in conjunction with a partial Lisfranc arthrodesis.
FIGURE 9 Axial view illustrating second and third metatarsal heads plantar to others. Maintenance of heads on the same transverse plane is important in prevention of abnormal forefoot pressures.

Radiographic Parameters

Anterior-posterior (AP), lateral and oblique views were required to evaluate injury to the Lisfranc joint (4,5). The oblique view allowed evaluation of the lateral joint complex (3). Comparison views of the contralateral foot assisted in the diagnosis as well as in the evaluation of reduction. The medial borders of the second metatarsal and intermediate cuneiform should be continuous on the AP and oblique views (Figs. 11A, 11B). The second and third intermetatarsal and intertarsal spaces should be continuous. On the oblique view the lateral edges of the third metatarsal and lateral cuneiform as well as the medial borders of the fourth metatarsal and cuboid should be continuous. The lateral view should not reveal a metatarsal more dorsal than its respective tarsal bone (Fig. 12). Widening of the first intermetatarsal space of greater than 2 mm. may be an indication of post-traumatic diastasis (5).

On the AP view the talometatarsal angle, metatarsus adductus angle, metatarsal parabola, intertarsal joints, and talonavicular relationship should be evaluated for pathologic changes. The metatarsal parabola was considered normal when it approximated 142.5 degrees (10).

On the lateral view the angles and relationships evaluated were the talometatarsal angle, the metatarsal declination angle, the alignment of the medial column, the calcaneal inclination angle, and the dorsal surfaces of the metatarsal bases relative to their respective tarsal bones.

Spontaneous reduction of a fracture-dislocation may occur after initial injury, requiring alternate imaging techniques if radiographs are inconclusive. Stress radiographs, bone scan, and magnetic resonance imaging (MRI), with and without contrast, were useful. However, with respect to patients who were being considered for a salvage procedure, only clinical examination findings and plain radiographs were required to determine which joints were to be fused.

Discussion

Injuries to the Lisfranc joint, even when treated initially, can develop pain and arthrosis that is nonresponsive to conservative measures (1,8). When this occurs, arthrodesis has been recommended (5,6,8,11). For the purpose of this paper, the Lisfranc joint was divided into medial and lateral complexes inasmuch as either three or five joints were fused. If diastasis or fracture between the medial and intermediate cuneiform was present at the time of the initial injury, intertarsal fusion was performed at the time of salvage. The quality of reduction after initial injury did not guarantee prevention of post-traumatic arthrosis. Subtle injuries often demonstrated osteoarthritis to a greater degree than profound fracture dislocation. Soft tissue integrity seemed to be a significant determinant in progression to
deformity. When diastasis had occurred, it became evident, after removal of internal fixation before arthrodesis, that, after open reduction, soft tissue integrity had failed (Figs. 13A-C). These patients can develop severe pain and deformity even when initial treatment is immediate.

Successful fusion of the Lisfranc joint does not guarantee a good functional outcome (6,8,12-14). Anatomic reduction relative to the radiographic parameters previously mentioned correlated with a good result. However, in a patient with an anatomically reduced foot, the presence of pain and disability would be considered a poor result.

The technique described allows for rigid internal fixation that does not need to be removed. It also precludes the need for bone grafting. With respect to the intertarsal joints, medial column, and rearfoot, adjunctive procedures may be required to improve the functional outcome (5,7). Posterior tibial tendon injury or dysfunction can occur in long-standing deformity. As a result of a progressive flat foot deformity, lateral impingement syndrome may develop as well.

In the absence of severe deformity and pain, fusion of the lateral two rays was not required for a good result. No significant difference was noted between the outcomes of partial joint complex fusion versus total joint complex fusion. If degenerative change was present in the lateral joint complex but without rigid positional deformity and pain, fusion was not performed. Pain did not occur in these patients after isolated fusion of the medial joint complex.

Clinical presentation and standard radiographs determined the joints to be fused. Technetium bone scan was not a factor when determining fusion sites, although it was useful for injuries in which spontaneous relocation occurred with no obvious radiographic abnormalities. It was noted that patients who, on bone scan, demonstrated increased signal through all 5 joints were not always symptomatic in the lateral joint complex.

Multiple skin incisions creates the risk of skin necrosis. Meticulous dissection and gentle retraction are essential to favorable outcomes. The single- or double-
incisional approach allows for a large area of skin and soft tissue between incision sites. The length of each incision allows for easy retraction resulting in less tension being applied to the skin. The length of the incisions described above result in improved orientation within the subcutaneous tissues.

Familiarity with the anatomy of the midfoot is crucial if the surgeon is to avoid nerve-related complications. The divisions of the superficial and deep peroneal nerves will be encountered through the medial incision. The medial neurovascular bundle may be directly plantar to the incision. Inspection should be performed for the sural nerve within the lateral site, although the nerve is normally lateral to the incision. Incision placement and atraumatic technique can have a profound effect on the complication rate. Blunt dissection just above the periosteal layer, helps identify most longitudinally oriented structures. Perforation of the first proximal perforating artery occurred during bone resection but did not lead to complications. Avoidance of this structure is advised.

Metatarsalgia may be encountered if positioning of the metatarsal heads at the time of fusion is not properly assessed. If accommodative devices fail to redistribute abnormal weightbearing stresses, elevating metatarsal osteotomies may be required. Diastasis between the first and second ray bases can occur after fusion. The strength and strain properties of the soft tissues within the midfoot are not quantified, and the amount of force required to cause injury to the soft-tissue structures is unknown. As a result of fusion of the first and second tarsometatarsal joints, the amount of stress between the medial and intermediate cuneiform will be increased. Soft tissue dissection proximal to the tarsometatarsal joints should be minimalized to avoid disrupting the integrity of the ligaments.

**Conclusions**

An extensive clinical examination, a thorough understanding of anatomy, and a reliable fixation technique are essential components to obtaining good results in Lisfranc salvage procedures. Cannulated partially threaded self-tapping cancellous screws with fluoroscopic assistance, provide an easy means for reduction, as well as compression, across the Lisfranc fusion sites. The use of the screw guide wires allows for quick and accurate adjustments before screw insertion. The single- or double-incisional approach reduces the chance of wound-related complications. Removal of screw fixation was not required for a good functional result. Post surgical pain can develop even when anatomic reduction was achieved. Additional procedures to the Lisfranc fusion may be required to provide an acceptable result. Deformities involving the medial column and rearfoot need to be assessed and addressed. With tarsal injury or diastasis, intertarsal fusion is recommended. Our technique for Lisfranc joint arthrodesis has proven to be an effective treatment for patients who do not respond to conservative care.

**References**
